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4 ERRORS 19 24 35 BOOK 36 39 51 55 ADDER
9 10 16 22
56 SYNDRUM & LIMITER
59

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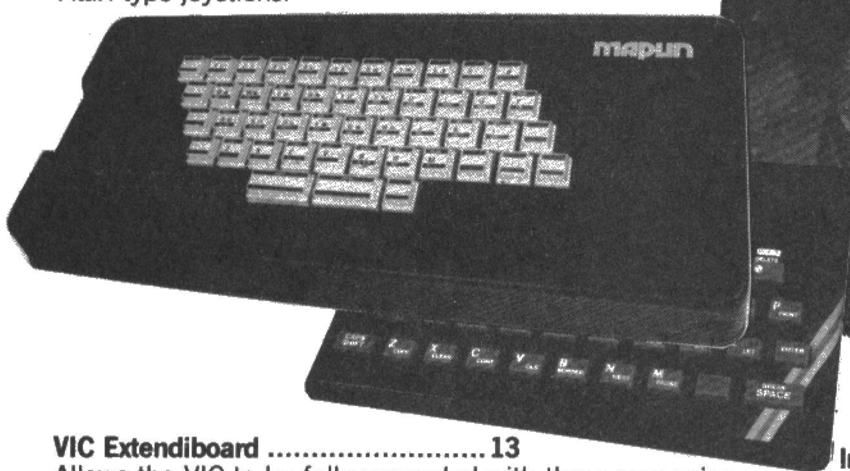
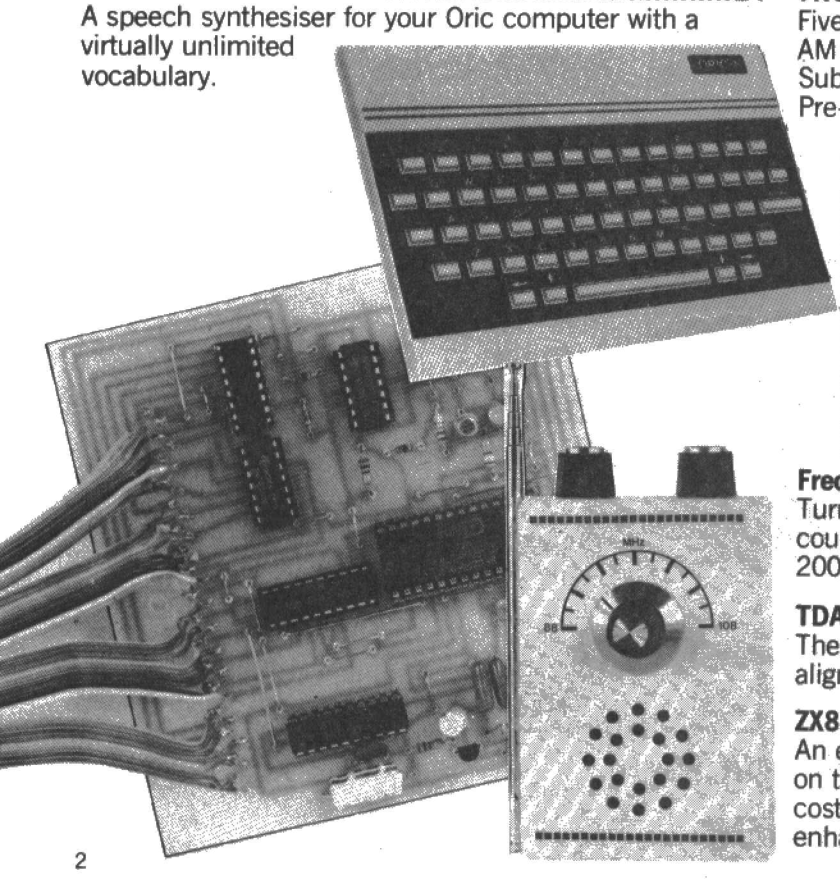
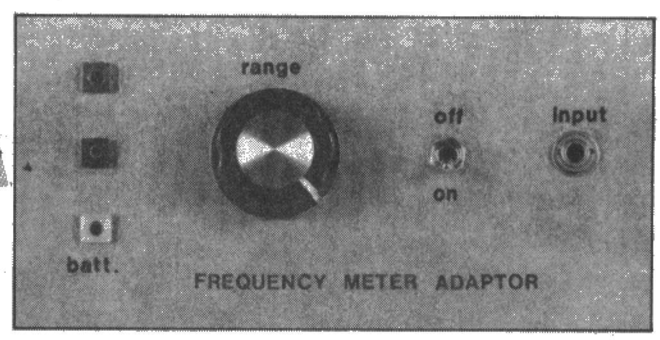
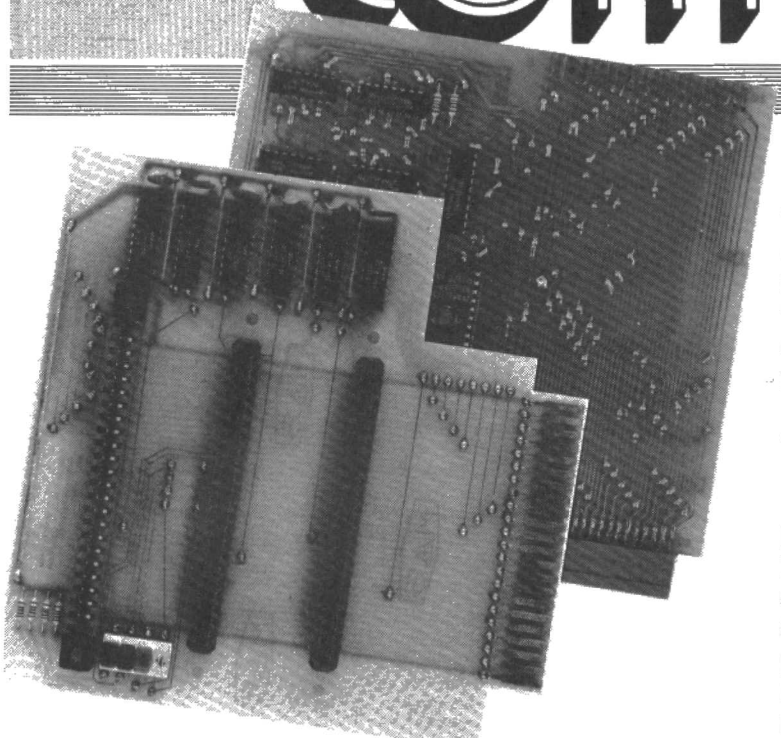
PROJECTS







CONTENTS



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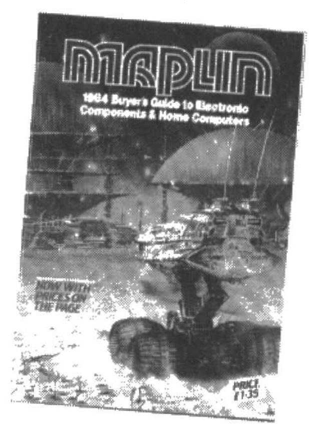

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Electronics
THE MAPLIN MAGAZINE
VOLUME 3 NUMBER 9

16 PROJECTS IN THIS BUMPER ISSUE

First of all, a warm welcome to all our new subscribers. A massive response to our invitation to subscribe to the magazine means that we have lots of new friends joining us this time. It certainly does make sense to subscribe to the Maplin Magazine, firstly because it's very inexpensive and tremendous value for money and secondly, because it's a quarterly, it's hard to remember when the next issue is due. Subscribing ensures that each issue is delivered to your door as soon as it's published.

Not having to print the complete Maplin price list has given us lots of extra pages that we've filled with new projects. In fact this issue contains a massive 16 projects, covering a wide range that we hope provides something interesting for everyone. There's a selection of computer projects, one of the most popular areas for construction projects at the moment, projects for use in and around the home, and some projects for the test bench.

On the centre pages you'll find a bumper selection of special offers, some with massive price reductions. In addition we have the first part of a new series about the kinds of test instruments that are used in electronics with advice on how to use them and descriptions of how they work, and the continuations of our other popular series.

As "Electronics" enters its third year we thought it was time to discover whether we've got the mixture about right for you. Thus our next issue contains a readership survey so that you can tell us what you think of the magazine as it is and how you think the magazine should progress.

On the 8th November our new shop in Southampton was officially opened by Lord Mabray-King a former Speaker of the House of Commons who recalled wheeling accumulators to this very shop some 50 years before to have them recharged! And the boy who served him in the shop at the time is now our manager, Ken Miles! Ken is looking forward to welcoming all Maplin's existing and new customers in Hampshire as well as his own existing customers to what has now become your own local Maplin store.

READERS LETTERS

Vic Talks Back

Dear Sir, Re: Vic Talk-back, March 83. Here are a couple of points which I think may be of use to other constructors of this project.

1) In the test program there are two pokes (line 1) which set up the I/O port thus; port A VIA no. 1 all lines input and port B VIA no. 2 line 7 input. These pokes are *not* required as the LRQ line (pin 1 on the PCB) is connected to the paddle port which is read by the 'VIC' chip' (6560) and not by the I/O port. This is because the digitized pot value can be read direct from the 6560 via a 65245. The final poke, (line 20) is also not required.

2) Some people may experience difficulty in obtaining the required wait before the SPO 256 is re-addressed. The wait is obtained from the paddle port: A value is obtained by the time taken to charge an internal capacitor. The capacitor would usually be charged by a pot in the paddle. In the Talk-back, the charging is obtained from the LRQ line going high. Sometimes problems can occur, the capacitor will not charge properly and the correct digitized value not returned. This can be cured by adding a 0.1uF mini-disc capacitor between Gnd. and LRQ (pin 9, IC3). This mod. should cure the problem.

R. BALL
Leigh-on-Sea, Essex

1. The unnecessary pokes were part of an earlier Program for a Prototype, and are not needed as you correctly point out.

2. We have not heard of any complaints regarding this problem and so cannot really make any suggestions. Any comments??

Dragon Dilemma

Dear Sir,

In your September/November edition of the magazine details were given of a Dragon 32 I/O port testing procedure. Having purchased the kit, I came unstuck whilst testing the relay switched ports and the dual opto port. In paragraph 2, simply typing: Poke 49155,52,:Poke 49154,1 Enter, LED 2 lights but LED 3 does not. This is because the O/P mode has not been initially specified. The correct procedure is:

Poke 49154, 255 O/P Mode
Poke 49155, 52 Enable port c
Poke 49154, 1 LED 3 illuminates
or
Poke 49154, 2 LED 4 illuminates.

Once the O/P mode has been specified checks on the relay contacts and the dual opto device can then be carried out.

I only mention this to you as there may be other puzzled purchasers of the Dragon I/O port wondering if their construction is at fault.

C. M. Drury
Somerton, Somerset

My thanks to Mr Drury for making this point. Unfortunately, while the test procedure was being written Port B Data Direction register had previously been set to O/P mode and was not mentioned in the text. The Access Routines Table (Page 26) shows required procedures for using Ports B and C, but for anyone else who may be confused with the tests, on Page 24, I suggest they try your amendment for correct results.

Micro Mania?

Dear Sir,

I found your latest issue (Sept-Nov) of Electronics most interesting except for the futher encrouchment of computer related artices.

I have subscribed (3 years) because I like doing business with Maplin and I found Electronics a worthwhile magazine. However I expect it to keep to the subject of electronics. Computer freaks are not really interested in electronics. They're primarily key bashing games players. But since it is obviously good business to cater to this sub-culture why can't you give them their own magazine like you did with Music Maker?

I shall really be disappointed to find that the promised additional 11 pages will be used for any further computer type articles. There are already far too many now! The new issue has a combined totally 15 project and feature articles out of which 6 are computer related, that is 40%. It is not fair or right that Electronics should go the way of all the other electronics journals especially since anyone beyond the games playing stage has learned that computers (personal types) in their present state of development and price are just expensive, trendy toys. I'm sure I'm not alone in requesting that Electronics magazine should be devoted primarily to electronics.

S. NORTH
Woodbridge

"Suggestions"

Dear Sir,

May I take this opportunity to thank you for your prompt attention to my orders over the last three years. There are some projects in which I am interested and suggest these for consideration by your magazine team.

1. The circuitry of my 12V camping lamp (XY 71N) no longer functions and this prompts me to ask if you have considered publishing a circuit which could be used with a 12V battery and tube (LQ 11M) to provide standby lighting.
2. I have heard for quite a while of "Atomic clocks", a receiver and time display accurate to the second, synchronised to a radio signal. Have Maplin considered offering a project kit which would make such a timepiece.

Some time ago I was looking for a reasonably priced zip-up tool case which after some searching I found. This has lace-up straps on one side for screwdrivers etc. and varying size pockets in the other for pliers, wire-cutters etc. Such an item, I suggest, would be a useful addition to your product range.

P.J. HARMAN
Surrey

We have considered both of the mentioned ideas. There is a possibility that we might publish a 12V camping light, (possibly in the next issue) although this will involve hand-winding coils.

The atomic clock project has been examined in the past, and although it represents a worthwhile project, it is by no means cheap.

The tool-case is a new addition in the new catalogue.

BBC B Builder

Dear Sir,

I read your article in the September issue of 'Electronics — the Maplin magazine' with great interest and you went most of the way towards solving my problems.

I wish to connect up additional Input/Output ports on the BBC model B computer. I will need a total of 48 ways, i.e. 3 6821 PIAs will do. These are only ever to be used as inputs and there is to be nothing else on the 1MHz bus at the same time.

I would be grateful if you can please let me know the best/easiest/cheapest way of doing that.

A.J. WOODS
Bucks.

Robert Penfold Replies.

Probably the most simple way of adding 6821s to the 1MHZ Bus would be to extend the circuit shown in Fig. 3 of the article. The 74154 (IC1) has sixteen ouputs, and as the circuit stands, only one of these is used (output 12 or C in hex). By using some of the other outputs it should be possible to add further 6821s. For example, gating output 0 (pin 1 of IC1) with the NPGFC line and using this to operate the CS2 input of an additional 6821, this device would be placed at ?&FC00 to ?&FC03 in the memory map. This gating could be achieved using two diodes plus a 1k resistor, as for the existing 6821. By using output 1 (pin 2) of IC1 in the same way for a third 6821, this would be placed at ?&FC10 to ?&FC13 in the memory map. Apart from the CS2 inputs of the additional 6821s, all their terminals would simply be connected in parallel with the existing 6821, and it is unlikely that any buffering would be needed with just three devices in use.

CORRIGENDA

Vol. 1 No. 4

Telephone Exchange: On the main P.C.B. (GB06G) R1, R2 and R3 must be soldered on the top as well as the bottom of the P.C.B.

Vol. 2 No. 8

SYNCHIME: In the parts list on page 11, R23 and R24 should be added to the 56K resistors, making a total of 4 required.

CODE LOCK: Looking on the rear of the flexi-cable of the membrane switch in figure two, the left hand connection goes to SKT3 pin 1 and the right hand connection goes to SKT3 pin 7.

Also, looking at Switch 1 connections to SKT1, when the switch is to the top it is in READ mode, when switched down it is in WRITE mode.

DRAGON 32 RS232/MODEM I/F: In figure two, on the legend of the P.C.B., the positive symbol for C7 should be closest to the edge connector.

Also, on page 56, in the text where reference is made to pins 1 and 5 of SKT1, Pin 1 should read Pin 5 and vice versa.

FIRST BASE: Figure 14 on page 64, should show 8 EX-NOR gates.

ZX Spectrum RS 232 Modem Interface (LK21X). It has been noted that some of the EPROMS supplied with this kit have been incorrectly programmed, (IC7, 2716/M7, Order No. QY57H). A simple test will reveal if the device is correct or not, and is as follows. Print PEEK 15156, If PEEK = 1, then the IC is incorrect, however if PEEK = 2, the device is correct. Should your EPROM be wrong, please return it to us for re-programming. The only effect caused by this programming error is the Baud speed, which has been set at 1200 instead of the correct 300. All kits supplied from this date will have the correctly programmed EPROM included.

SPECTRUM KEYBOARD

By Dave Goodman

- ★ Full size, Full travel, 47 Keys
- ★ Multi colour legend for keys
- ★ Single key mode selection
- ★ Plugs directly into expansion port
- ★ Absolutely no soldering or dismantling of the Spectrum is required
- ★ Can accept Atari-type Joysticks

A full size keyboard with positive action mechanical keys, which simply plugs into the Spectrum expansion socket. Additional single key 'mode' selection is featured for GRAPHICS, SHIFT LOCK, CAPS LOCK, DELETE and EXTended keyboard; also a spare key is fitted which can be wired for personal requirements, such as system reset or interrupts. Atari type 'joysticks' can be fitted, with the addition of one or two (left/right) PCB plugs, thus allowing faster control of your programs and high speed games.

The keyboard connects to the Spectrum using a moulded cable and adaptor unit, which has an extension 2 x 28 way edge connector. Peripheral devices can still be fitted and all Maplin Spectrum projects will function normally with this system.

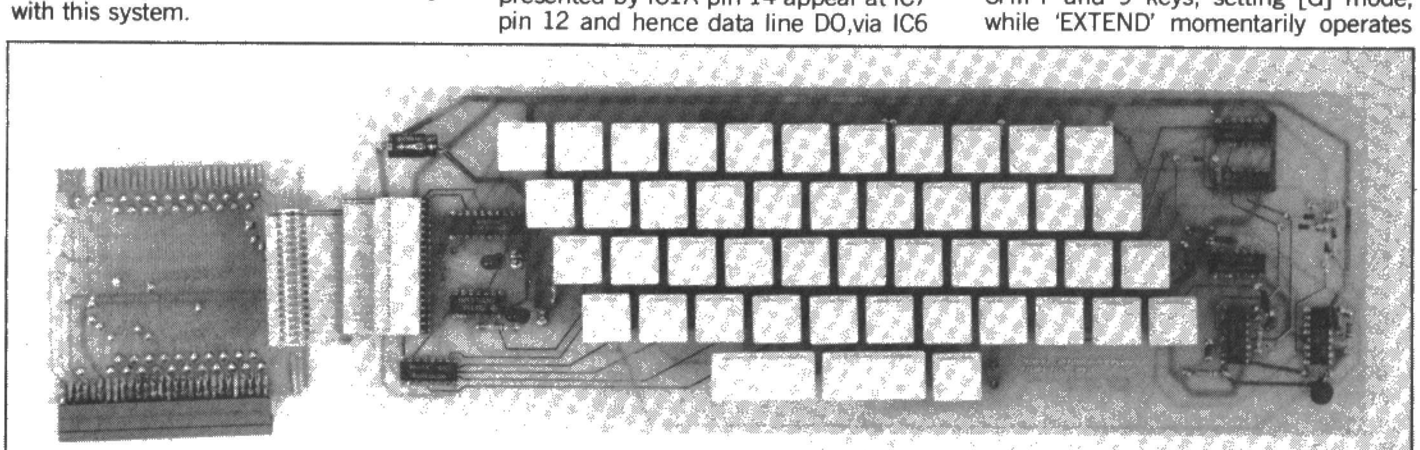
Circuit Description

Keyboard scanning is initiated with an I/O request from the Spectrum ULA I/C during a Z80 READ cycle and occurs when address line A0 is low 0V.

IC2 A, B decode this condition and enable both Address and Data line Buffers IC1, 6. The keyboard is scanned horizontally and vertically to register keys pressed at the cross points of the matrix. To simulate correct multi-key operations for the five 'mode' select keys, a tri-state buffer IC8 and open collector output buffer IC7 are used, which make the appropriate cross connections when active.

Caps lock mode is set by operating flip-flop IC4A. Pic 7 latches low and IC8A is enabled by D1. Scanning pulses presented by IC1A pin 14 appear at IC7 pin 12 and hence data line D0,via IC6 pin 9. Pull up resistor R5 supplies a high impedance +5V for positive going signals as IC7 can only sink current and not source it. SHIFT LOCK, functions in a similar manner by enabling IC8D from D2 and IC4B. LED 2 operating shows this mode is selected and also holds 'CAPS LOCK' key high from IC4B Pin 10, thereby preventing selection of CAPS LOCK when SHIFT LOCK is active. Spectrum owners will realise that extended keyboard mode is selected when operating both these keys together.IC4A Pin 6 also prevents 'SHIFT LOCK' from being selected when 'CAPS LOCK' is active.

IC5A and B are both monostables which apply a single negative going, 75ms pulse, when keyed, 'GRAPHICS 2' momentarily operates IC8A,C or CAPS SHIFT and 9 keys, setting [G] mode, while 'EXTEND' momentarily operates



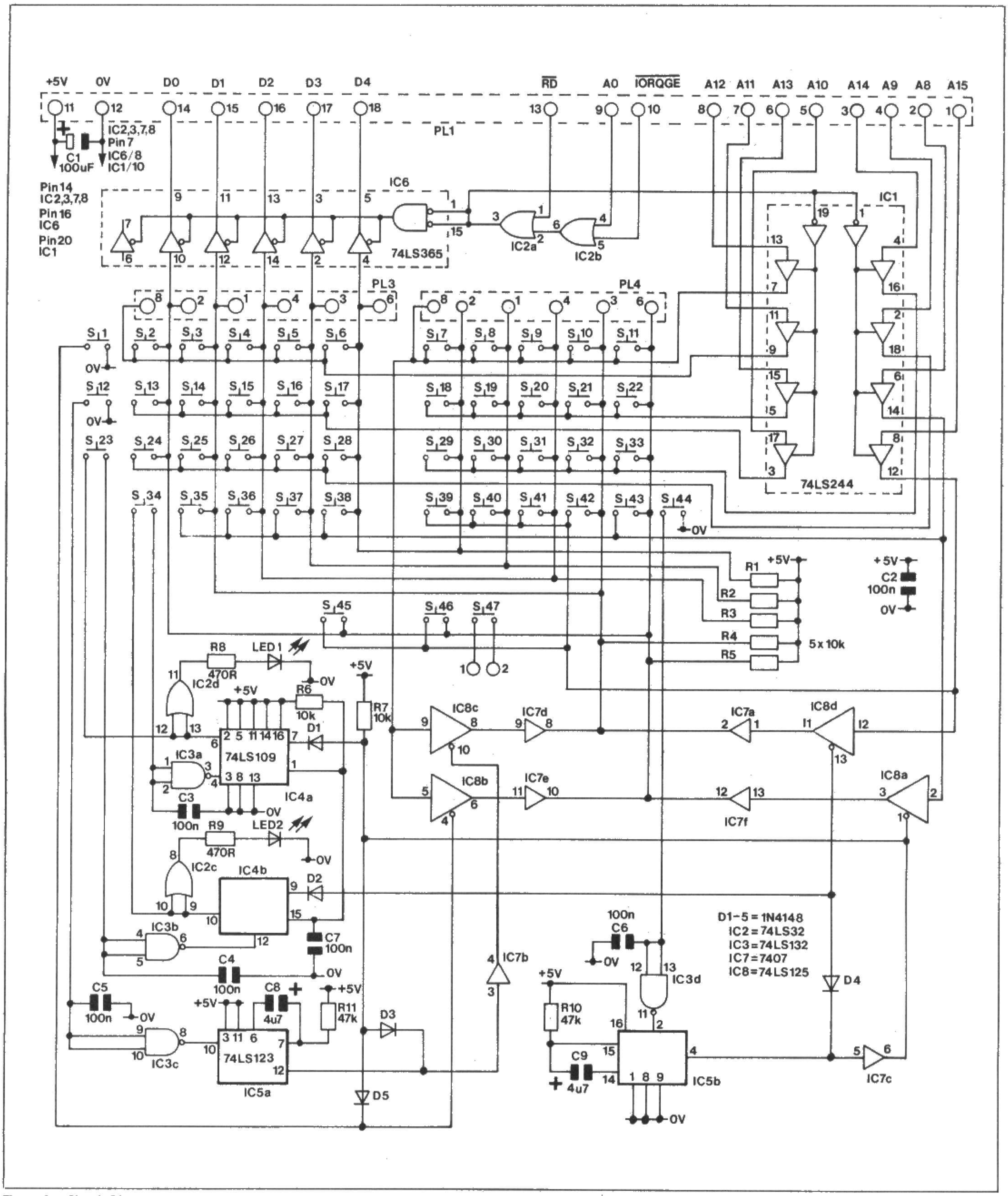


Figure 1. Circuit Diagram

IC8A and IC8D setting [E] mode.

Construction (Keyboard)

Begin construction by fitting resistors R1 to 11 on the board. Diodes D1 to 5 are now bent to shape and inserted into their respective positions. A white line drawn on the legend represents the cathode band, printed at one end of the diode which must be fitted correctly. Next insert IC's 1 to 8. Sockets are not necessary here although they can be fitted if so desired. Fit capacitors C1 to 9 noting that C1, 8 and 9 are polarized and must be orientated correctly. Solder all components onto the PCB - side 2 and remove excess wire etc. This board is double faced and all holes are plated through joining tracks together on both sides so ensure that components are correct before soldering, otherwise they can be difficult to remove afterwards.

Now insert PL1, with right-angled terminals facing out towards the end of the PCB, and mount all 47 keys. Fit 45 single and 2 double key tops (SPACE BAR), which may need slight re-adjustment if they appear twisted, and finally fit LEDS 1 and 2. Solder remaining components, clean excess flux or solder from the board using suitable solvents, and make a good inspection looking for poor joints and track shorts. This is well worthwhile and may help to prevent damage when power is applied.

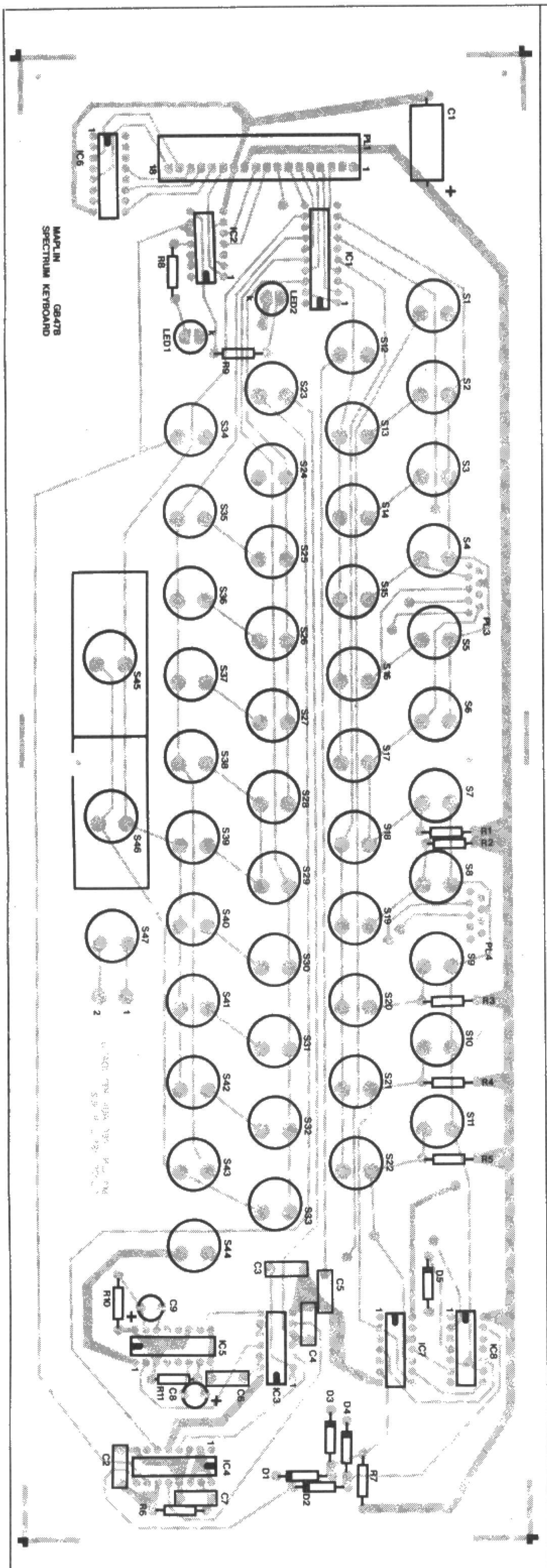


Figure 2. Circuit Board Layout

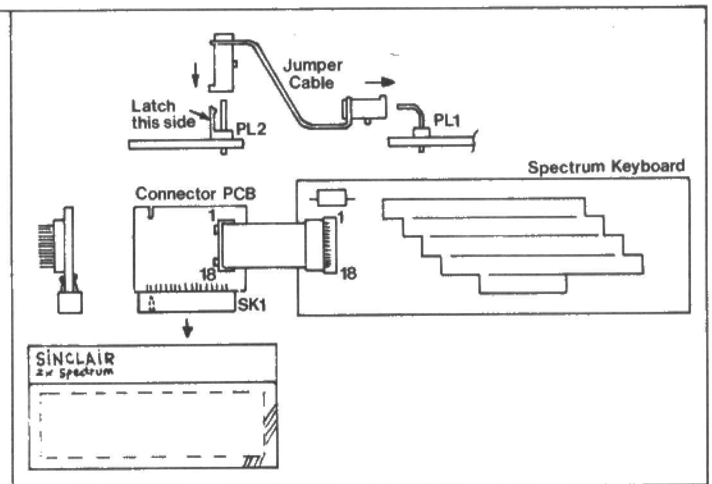


Figure 3. Connecting to Spectrum

Spectrum Keyboard

S1	Delete	S24	A
S2	1	S25	S
S3	2	S26	D
S4	3	S27	F
S5	4	S28	G
S6	5	S29	H
S7	6	S30	J
S8	7	S31	K
S9	8	S32	L
S10	9	S33	Enter
S11	0	S34	Caps Lock
S12	Graphs 2	S35	Z
S13	Q	S36	X
S14	W	S37	C
S15	E	S38	V
S16	R	S39	B
S17	T	S40	N
S18	Y	S41	M
S19	U	S42	Symbol Shift
S20	I	S43	Caps Shift
S21	O	S44	Extend
S22	P	S45	Space
S23	Shift Lock	S46	Space
		S47	Spare

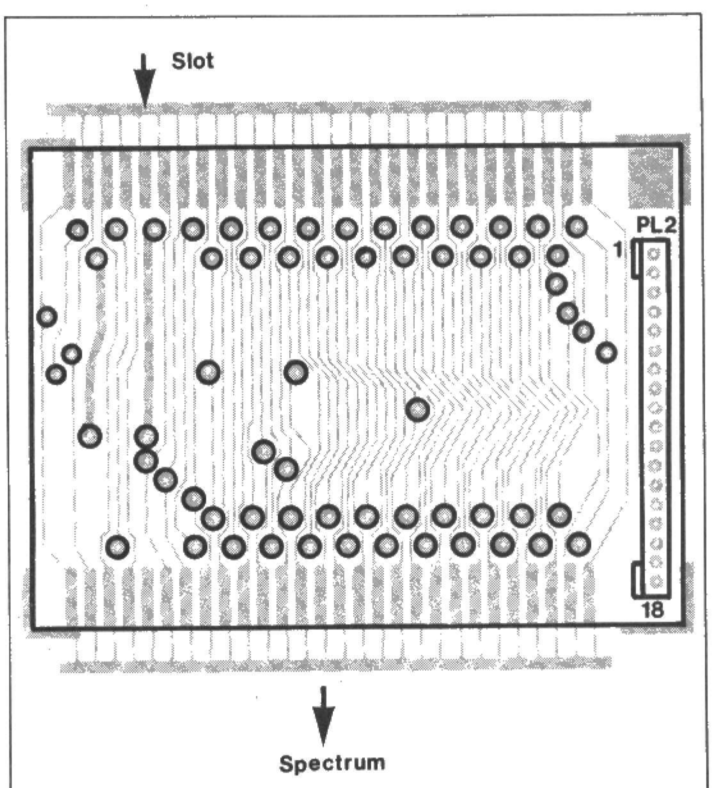


Figure 4. Adaptor Circuit Board

Construction (Adaptor PCB)

There are sixty four track pins to be inserted into all holes marked with a circle, and they must be soldered onto both sides of the PCB. Push them down onto the pads with a soldering iron to ensure they protude through the other side before soldering. Position a 2 x 28 way socket over the edge connector without a slot cut in position five. A blank pad exists in this position, which aligns with the socket locating peg. Solder all fifty four terminals onto the edge pads very carefully and avoid solder shorts between them. Finally, insert the 18 way vertical Minicon socket and solder in position. Check for shorts etc. on the board and insert into the Spectrum expansion socket on the back panel.

Testing

With only an adaptor unit in place, apply power to the computer and television. Check that the Spectrum keyboard functions normally. Switch off and fit the connecting cable between adaptor and remote keyboard PCB. Reapply power. The Sinclair copyright notice should appear, as usual, but the Spectrum keyboard will now be inoperative. Try all keys in every mode to ensure correct operation, see TABLE 1.

KEY		OPERATION
Delete	—	Erases previous character
Graphics 2	—	Cursor [G], Graphic symbols
Shift Lock	—	Red 'On Key' symbols
Caps Lock	—	Upper case characters
Extend	—	Cursor [E], Green 'Off Key' functions

Table 1. Modes of operation for the Keyboard.

The Extend mode remains until a function is selected, whereafter the keyboard returns to normal operation. Graphics 2, Shift Lock and Caps Lock remain in the mode selected until re-operated and Delete can be either single or repeated operation.

Joystick Ports

Plugs 3 and 4 are wired to suit Atari type joysticks and can be fitted into the PCB as an optional extra. PL3 simulates keys 1 to 5 and PL4 simulates keys 6 to 0 as shown in TABLE 2.

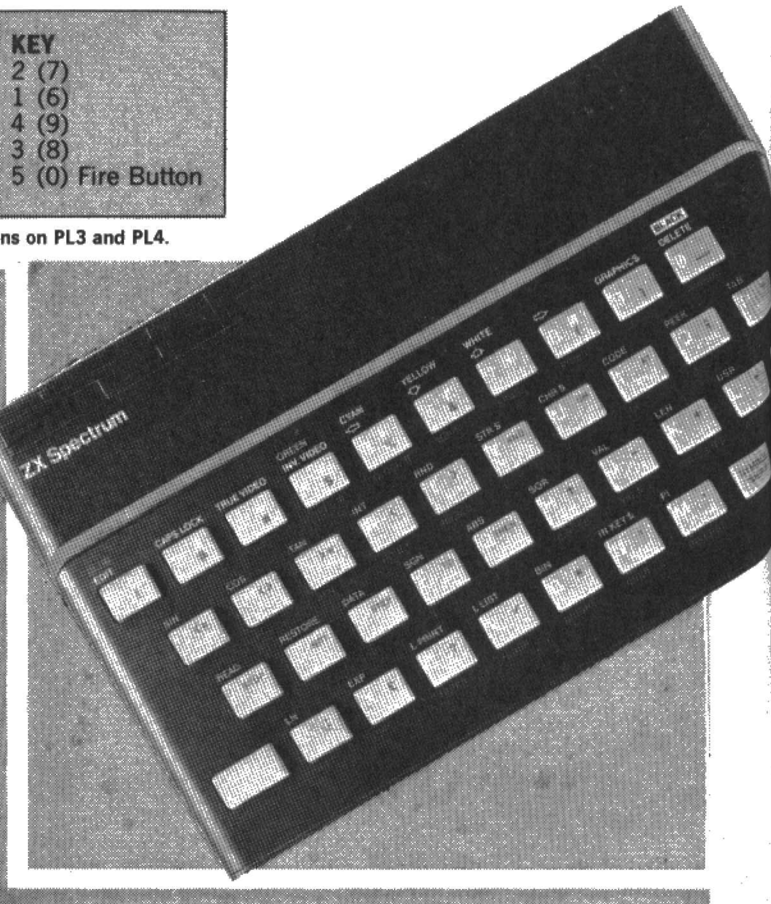
PL3 — (4)	KEY
Pin 1	2 (7)
Pin 2	1 (6)
Pin 3	4 (9)
Pin 4	3 (8)
Pin 6	5 (0) Fire Button

Table 2. Key Simulations on PL3 and PL4.

Case Details

The keyboard can be fitted into a case, designed specifically for the purpose, and held in place with six plastic snap rivets. If plugs 3 and 4 are fitted, slots will need to be cut into the back panels allowing clearance for joystick plugs, otherwise the PCB will not fit!

Finally, for the less adventurous, a complete keyboard, minus plugs 3 and 4, is available from us (see Parts List for details and prices).



SPECTRUM KEYBOARD

Resistors — All 0.4W 1% metal film			
R1-7 inc	10k	(7 off)	(M10K)
R8,9	470R	(2 off)	(M470R)
R10,11	47k	(2 off)	(M47K)
Capacitors			
C1	100uF 10V Axial Electrolytic		(FB48C)
C2-7 inc	100nF Disc Ceramic	(6 off)	(BX03D)
C8,9	4u7F 16V Tantalum	(2 off)	(WW64U)
Semiconductors			
D1-5 inc	1N4148	(5 off)	(QL80B)
IC1	74LS244		(QQ56L)
IC2	74LS32		(YF21X)
IC3	74LS132		(YF51F)
IC4	74LS109		(YF44X)
IC5	74LS123		(YF48C)
IC6	74LS365		(YH11M)
IC7	7407		(QX76H)
IC8	74LS125		(YF49D)
LED1,2	Red LED	(2 off)	(WL27E)
Miscellaneous			
S1-47 inc	Keyboard Switch	(47 off)	(FF61R)
	Keytop 1	(45 off)	(FF62S)
	Keytop 2	(2 off)	(FF63T)
	Spectrum Keytop Print		(YK77J)
PL1	18 way R.A Minicon Plug		(BK84F)
	Spectrum Keyboard P.C.B.		(GB47B)
Optional			
	20 pin DIL Skt		(HQ77J)
	16 pin DIL Skt	(3 off)	(BL19V)
	14 pin DIL Skt	(4 off)	(BL18U)
PL3,4	R.A. D-Range 9-Way Plug	(2 off)	(FG66W)

ADAPTOR

PL2	18 Way Latch Minicon Plug		(BK85G)
SK1	2 x 28 way P.C. Edgecon		(FG23A)
	18 Way Jumper Cable		(BK86T)
	Spectrum Keyboard Connector P.C.B.		(GB48C)
	Track pin	(2 pkts)	(FL82D)

SPECTRUM CASE

	Case		(XG35Q)
	* Snap Rivet	1 pkt	(BK87U)
	* Velcromount	(2 off)	(HB21X)
	* Stick on feet	(2 off)	(FW38R)

** These items are included in the Case (XG35Q).*

A complete kit of all parts to build the Keyboard (excluding optional parts) is available
Order As LK29G - Price £28.50

A complete kit of all parts for the adaptor is available.
Order As LK30H - Price £6.50

A ready-built Keyboard is available, including adaptor and case.
Order As XG36P — Price £44.95

FIRST BASE

by Mike Wharton **A Beginner's Guide to Logic Design Part Four**

Hexadecimal numbers

As promised in the last article, we shall commence this time with a short "refresher" on hexadecimal numbers or hex. for short. We are all fairly familiar with the denary, or decimal, system, where the number base is ten. We had a brief encounter in the last article with the binary system, where the number base is two. In the hex. system the number base is sixteen. There are some very good reasons for using such a system, rather than the more usual decimal one, which we shall go into in a moment. One potential 'problem' with this method of numbering is that the same symbols as those for the decimal system are used, plus the first six letters of the alphabet. So as to be sure which number system is intended, it is usual to include some form of specifier along with the hex. number, in order clearly to distinguish it from a decimal value. Figure 1 shows the relation between decimal and hex. numbers. If we take decimal 42 as an example, this converts to 2A in hex., ie (2x16=32) + (Ax1=10). So 32+10=42. This would typically be written as 2AH, £2A or &2A, where the 'H', '£' and '&' are being used to indicate that the value is in hex. This will be familiar territory to those readers who are interested in computing, and it is recommended that anyone wanting to delve further into the theory of related number systems look up the subject in any of the books on computing. Again, some of you may be forgiven for thinking that we are wandering away from

Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
0	0	4	4	8	8	12	C
1	1	5	5	9	9	13	D
2	2	6	6	10	A	14	E
3	3	7	7	11	B	15	F

Figure 1. Decimal to Hex Conversion Table.

the subject of digital logic design! In fact the hex. system springs more naturally from the binary way of numbering, which is the basis of practically all digital counting techniques. Before we examine some practical devices, let us just look at how digital signals are used in counting; Fig. 2a shows the simplest situation, where one 'line' can be used to signify two values, that is either a binary 0 or 1. Fig. 2b shows how the range of binary numbers can be increased by the use of two lines; each line can adopt either of the two binary states and hence may be used to

(a) A = Logic 1 (+5V)
or A = Logic 0 (0V)

(b) A=0 or 1
B=0 or 1

A	B	Value
0	0	0
0	1	1
1	0	2
1	1	3

(c)

A	B	C	D	Value
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9
1	0	1	0	10
1	0	1	1	11
1	1	0	0	12
1	1	0	1	13
1	1	1	0	14
1	1	1	1	15

Figure 2. Digital Counting.

indicate values from 0 to decimal 3. The addition of one more line to the system doubles the range of values which can be shown, thus with four lines it is possible to indicate up to decimal 15, as in Fig. 2c. This is where the convenience of counting in a base of sixteen comes into its own. Thus, with a group of four connecting wires or 'bus', the sixteen values from 0 to 15, or 00 to 0F hex. can be produced. In many home computers a bus consisting of 8 lines is used, allowing the 256 values from 0 to 255, or 00 to FF hex. to be transmitted as data.

Clocks

When numbers are to be used for counting we generally need something to count. Some 'digital' counting methods use fingers, but we will try for a little more sophistication! In sequential logic designs, the logic levels change as pulses are fed through the system. These pulses are produced by special oscillators, often called clock oscillators or, simply, clocks. The connection with the clock on the wall is that the duration of these clock pulses sets the speed of operation of the circuitry; the faster the clock then the quicker the circuit operates. In the analogue world, an oscillator will usually be required to produce the smooth curve of a sine wave. In digital circuits such a wave-form would be an embarrassment, since they are slowly changing voltage levels present between the positive and negative peaks. What is required is a wave-form which shows rapid transitions between logic 0 and logic 1; this is found in the square wave, shown in Fig. 3. Ideally the transitions, known as the rise time and fall time, should be as rapid as possible. A good square wave oscillator may produce rise and fall times of a few nanoseconds, although for general experimentation times much longer will do.

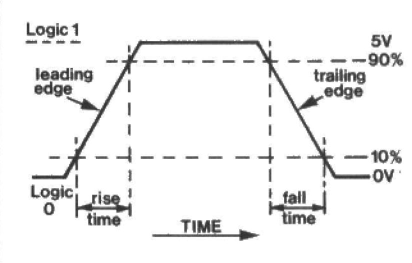


Figure 3. Square Wave.

Simple Clock Oscillator

The simplest clock for use in logic designs could be just a push switch, connected as shown in Fig. 4. The main drawbacks with such a simple method are two-fold; a) contact bounce when the switch is opened and closed will give rapid, multiple pulses, rather than the single pulse intended and, b) your finger will soon get tired if a continous

Continued on page 12

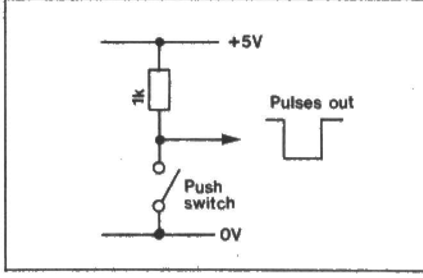
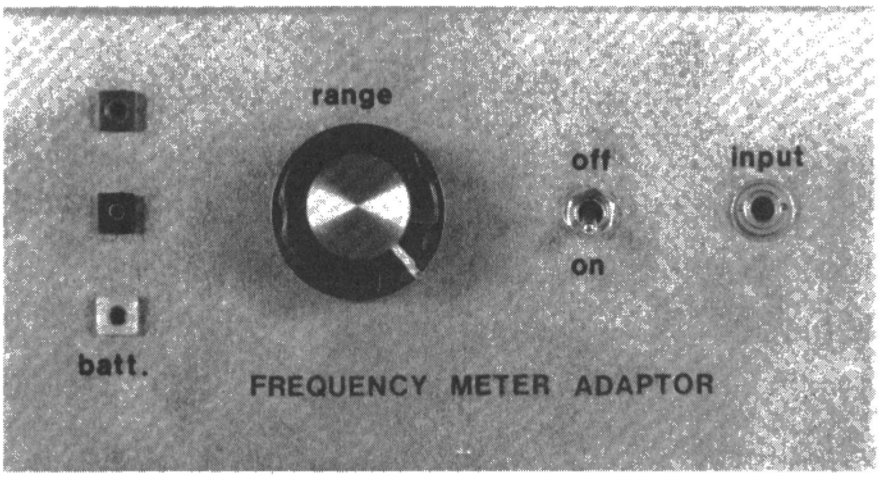


Figure 4. Simple Switch Pulser.

Frequency Meter Adaptor



★ Turns Your Digital Multimeter into an Accurate Frequency Counter
★ Ideal For Measuring Audio Frequencies and Beyond
★ Battery Operated ★ Easy To Use

by Robert Penfold

A sophisticated frequency meter capable of highly accurate measurements at frequencies into the VHF range is extremely useful for anyone who is involved in radio communications, or certain specialised fields of audio frequency electronics. However, for most audio frequency work a relatively simple frequency meter is adequate, and costs substantially less than a high specification DFM.

This simple and inexpensive project is a frequency to voltage converter, which can be used with a digital multimeter switched to the 0 to 1.999 volts range to give a four range frequency meter having full scale values of 199.9Hz, 1.999kHz, 19.99kHz, and 199.9kHz. The unit will also operate with an analogue multimeter having a suitably low D.C. voltage range, but if the full scale voltage is less than 1.999 volts the full scale value of each frequency range will be reduced accordingly. The accuracy of the unit is largely dependent on the quality of the multimeter with which it is employed, and the accuracy with which the unit is calibrated, but results should be more than adequate for most audio frequency testing.

LM2917N

The LM2917N is a frequency to voltage converter IC which has a dual purpose comparator/amplifier output stage which enables the device to activate a relay or similar load if the input frequency exceeds or falls below a certain level, or to act as a straightforward converter. In this application it is just a simple frequency to voltage conversion that is required. Figure 1 gives pinout details of the LM2917N and shows the internal stages of the device.

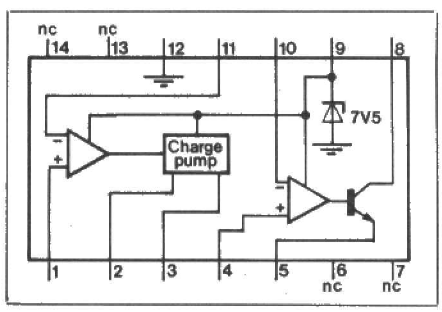
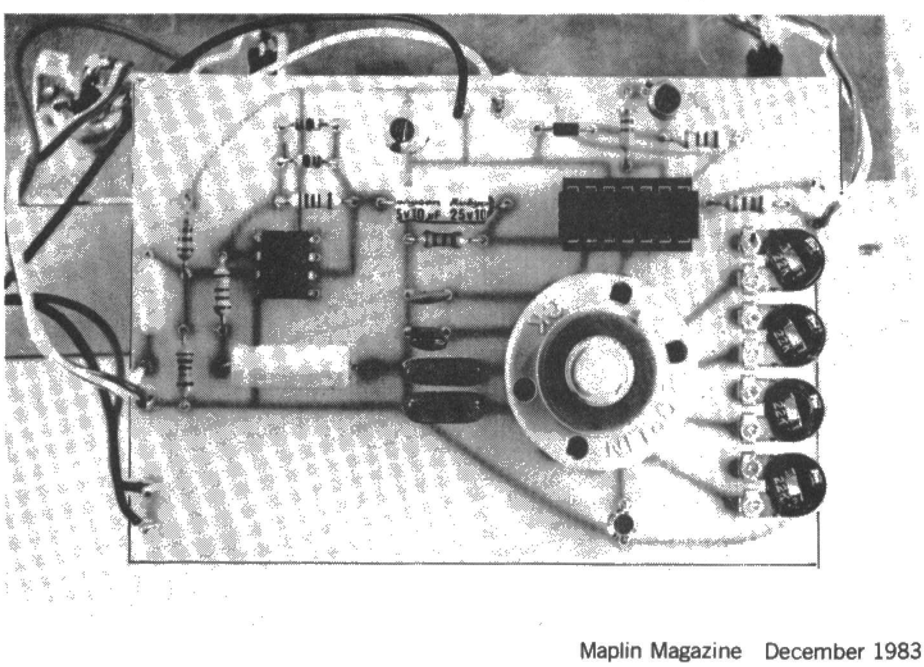


Figure 1. The LM2917 pinouts and internal circuit blocks.

An operational amplifier is used at the input, and this stage has built-in hysteresis which gives the circuit excellent immunity to noise on the input signal. The frequency to voltage conversion is carried out by a charge pump circuit which requires only three discrete components. This stage offers frequency doubling which enables a fast response time and a low ripple output to be obtained. The output operational amplifier has both inputs accessible and drives an npn transistor which can be used in either the common collector or emitter follower mode. A 7.5 volt zener diode enables the supply to be stabilised in critical applications.



The Circuit

Figure 2 shows the circuit diagram of the adaptor. IC1 is used as a simple non-inverting amplifier which boosts the sensitivity of the circuit by a factor of 11 times, and enables the unit to operate with an input as low as 2 millivolts RMS. This stage also gives the unit a reasonably high input impedance of about 500kΩ. D1 and D2 clip the output signal of IC1 to prevent an excessive input signal being applied to IC2.

R5 is used to bias the input of IC2 to the negative supply rail. Four switched timing capacitors (C4 to C7) give the unit its four measuring ranges, and a separate calibration preset for each range (RV1 to RV4) ensures good accuracy on all ranges. The third discrete component in the charge pump circuit is filter capacitor C8, and the value of this component is chosen to give a suitable compromise between response time and output ripple. 100pF is the lowest acceptable value for the timing capacitor, and 10kΩ is about the lowest usable value for the filter (calibration) resistor, and this limits the maximum operating frequency of the unit to about 200kHz. If the input signal level is inadequate to operate the input stage and charge pump circuit properly the later fails to give an output voltage. This makes it obvious that an inadequate input level is present and prevents misleading readings from being obtained.

The output from the charge pump circuit is connected to the non-inverting input of the operational amplifier at the output of IC2, and this is used as a buffer amplifier having the npn transistor as an emitter follower output stage. At SK2 and SK3 this gives a low impedance output voltage which is proportional to the input frequency.

In this application a well regulated supply voltage is essential if accurate and consistent results are to be obtained. A single 9 volt battery is inadequate to give such a supply since the internal zener diode of IC2 is a 7.5 volt type, and for this to operate efficiently the supply input potential must always be at least one volt or so higher than this zener voltage. The circuit is therefore powered from two 9 volt batteries in series giving a nominal 18 volt supply, but this is fed to IC2 via a simple series regulator which is comprised of TR1, R8 and D3. The use of this regulator plus the internal zener diode of IC2 gives excellent stability with no discernable change in frequency reading if the supply is varied from 14 to 20 volts. SK4 enables the total battery voltage to be checked easily by providing an external test point. The current consumption of the circuit is about 12 milliamps.

Construction

Most of the components, including S1, are mounted on the printed circuit board, as illustrated in Figure 3. Assuming S2 is an ordinary rotary switch having tags rather than the printed circuit pins, the ends of the tags must be trimmed off using a pair of side cutters to leave what are effectively printed circuit pins that will fit into the board without too much difficulty. However, be careful to leave these pins as long as possible by trimming away no more than is absolutely necessary. In other respects construction of the board is quite normal.

An aluminium box measuring about 133 by 70 by 38mm makes a neat but inexpensive housing for the unit. The front panel layout can be seen by referring to the photographs, but from the electrical point of view the layout is not critical. However, it is advisable not to radically depart from this layout unless you

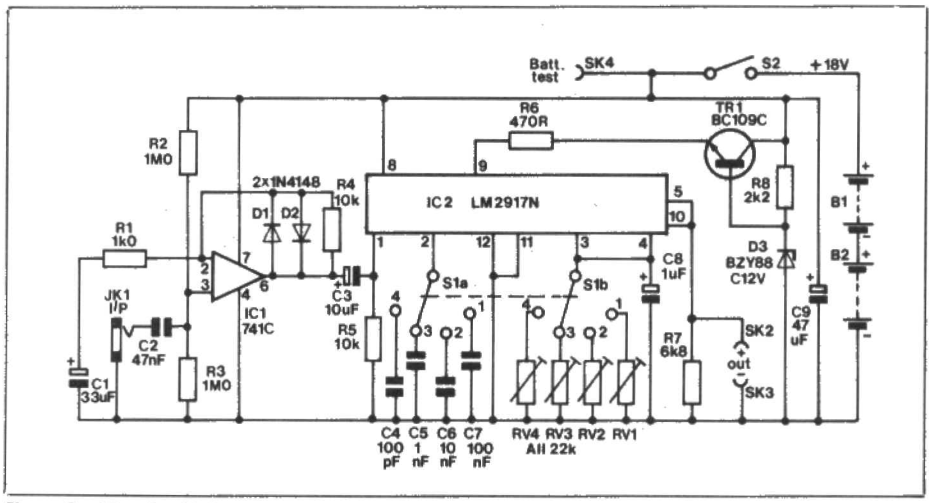


Figure 2. The circuit diagram.

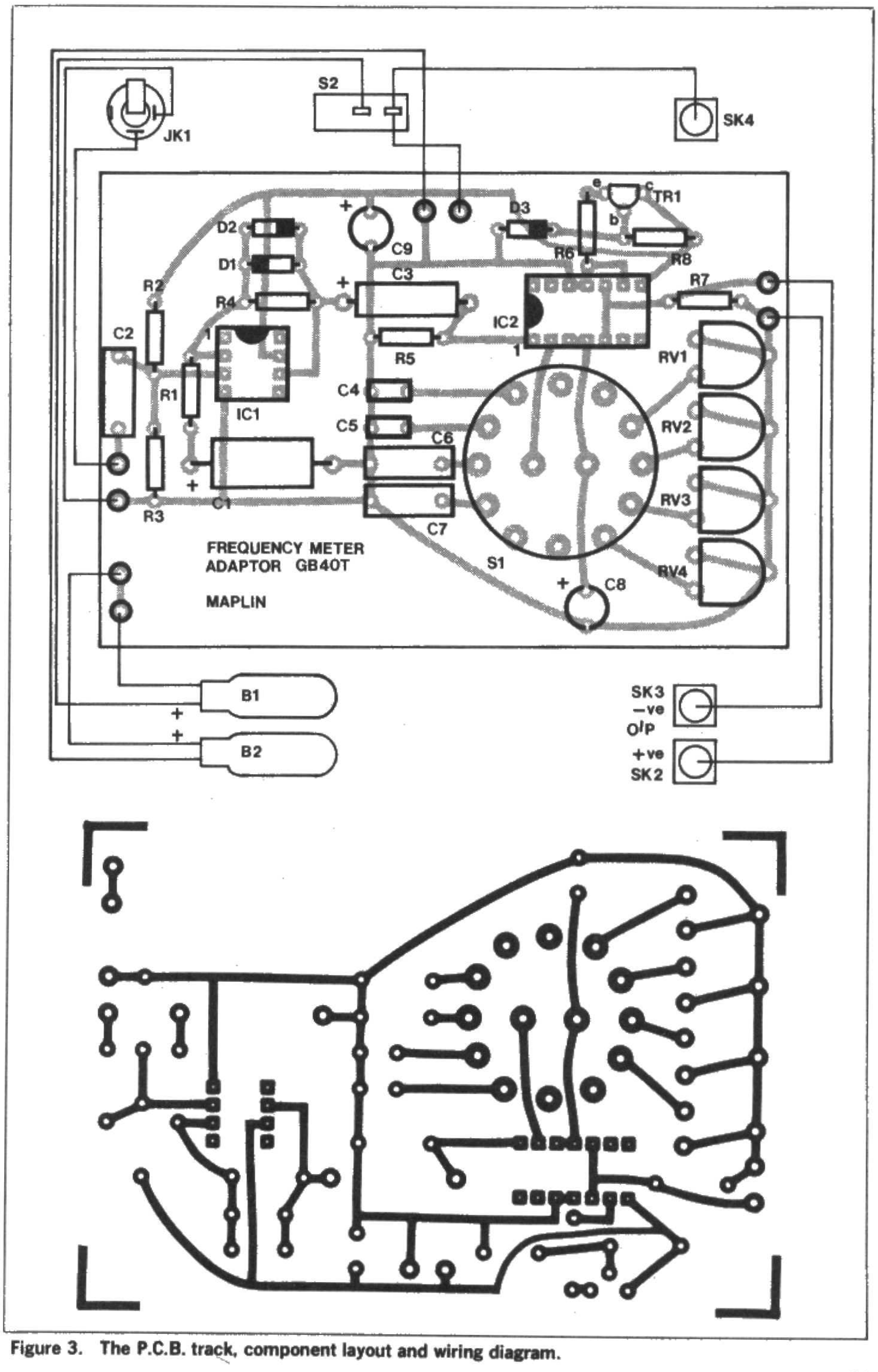


Figure 3. The P.C.B. track, component layout and wiring diagram.

are quite sure that everything will physically fit into place properly. The board is fixed in place inside the case when S1 is fitted onto the front panel, and no additional mounting is required, but wire the board to the rest of the unit before finally fitting it in place. There is sufficient room for the two batteries to fit in the space beneath the board, and a piece of foam material can be used to hold them in position.

Calibration

Ideally the unit should be calibrated with the aid of a crystal calibrator having output frequencies of 100Hz, 1kHz, 10kHz and 100kHz so that RV1 to RV4 can be adjusted to give the correct readings from the multimeter which is fed from SK2 and SK3. This is not essential though, and any signal source which provides known frequencies can be used as a calibration source. For optimum accuracy the calibration frequencies should represent about 50% or more of the full scale reading of the range concerned. A good quality A.F. signal generator should have adequate scale accuracy, or an alternative is to use a synthesiser or other musical instrument as the signal source. For example, the 'A' above middle C is at a frequency of 440Hz, with every octave increase in pitch giving a doubling of frequency, and each fall of one octave giving a halving of frequency.

Readings obtained using the unit are not significantly affected by the input waveform, and accurate results should be obtained with both symetrical and pulse signals. The circuit is also largely unaffected by the amplitude of the input signal with the output falling to zero in the unlikely event of an inadequate input signal level, but signals of more than about 10 volts peak to peak will overload the unit and could give erroneous results. It would therefore be advisable to use an attenuator probe when measuring very high level signals.

correction from Vol 3 No 10 p. 36

PARTS LIST FOR FREQUENCY METER ADAPTOR

Resistors — All 0.4W 1% metal film unless specified.

R1	1k0		(M1K0)
R2,3	1M0	2 off	(M1M0)
R4,5	10k	2 off	(M10K)
R6	470R		(M470R)
R7	6k8		(M6K8)
R8	2k2		(M2K2)
RV1-4	22k hor preset	4 off	(WR59P)
Capacitors			
C1	33uF 16V axial electrolytic		(FB35Q)
C2	47nF polyester		(BX74R)
C3	10uF 25V axial electrolytic		(FB22Y)
C4	100pF ceramic		(WX56L)
C5	1nF polycarbonate		(WW22Y)
C6	10nF polycarbonate		(WW29G)
C7	100nF polycarbonate		~~(WW42V)~~ WW41V
C8	1uF 100V PC electrolytic		(FF01B)
C9	47uF 25V PC electrolytic		(FF08J)

Semiconductors			
D1,2	1N4148	2 off	(QL80B)
D3	BZY88C12V		(QH16S)
TR1	BC109C		(QB33L)
IC1	uA741C		(QL22Y)
IC2	LM2917N		(WQ38R)
Miscellaneous			
S1	Switchpot 2 pole 6 way		(FH43W)
S2	SPST ultra min toggle		(FH97F)
JK1	Jk SKT 3.5mm		(HF82D)
SK2	2mm skt red		(HF47B)
SK3	2mm skt black		(HF44X)
SK4	2mm skt yellow		(HF49D)
	PC Board		(GB40T)
	PP3 battery clip	2 off	(HF28F)
	Control Knob		(YX02C)
	Wire		(BL00A)
	Veropin 2145	1 pkt	(FL24B)
	Box type AB7		(LF08J)

A complete kit of all parts, excluding the case, is available. Order As LK20W Price £8.99

First Base *Continued from page 9*

stream of pulses is needed! Nevertheless, it is a very useful way of 'single-stepping' pulses through a circuit if bounce is eliminated. A method of doing this using a single chip is shown in Fig. 5, but again this may not be necessary for simple experiments. A clock oscillator providing a series of square pulses can conveniently be made using the common 555 timer chip. There must have been umpteen designs published showing how this device may be used

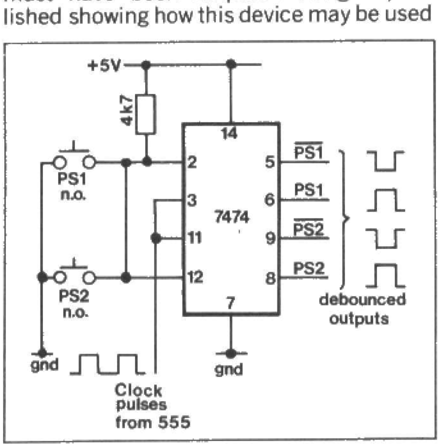


Figure 5. Debounced Push Switch.

in the astable mode. A suitable circuit is shown in the Maplin Catalogue along with the data indicating how the component values may be modified to alter the clock frequency. Fig. 6 shows a 555 based clock oscillator which will give an output of around 60 Hz.

Counting Pulses

Having devised a method of producing pulses, the next step will be to look at digital methods of counting them. Of course, if you are producing pulses by pushing a switch you can count them as you go along, but this is not really the name of the game. Fig. 7 shows the pin-out of a 7493 four bit binary counter chip. The drawing gives little clue as

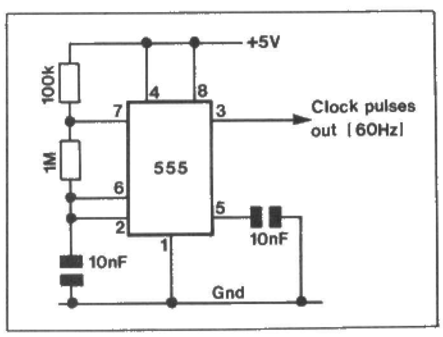


Figure 6. 555 Clock Oscillator.

to what is going on inside the device, but at this stage this is not important. What is important is that we understand how to connect it up correctly. One point to notice immediately is that the connections to +5 volts and Ground are on different pins from many 74 type chips, viz. 5 & 10 respectively. The 7493 has four counting stages altogether, with the output from the first stage being available separately. The outputs and inputs of the last three stages are connected together internally. The train of pulses from a push switch or clock oscillator is fed into pin 14, Input 'A'. The first stage divides the pulse rate by two and the output appears at pin 12, Qa. For the remaining stages to be brought into the chain, this output is fed back into Input 'B' at pin 1. The outputs from the subsequent stages then appear at pins 9, 8

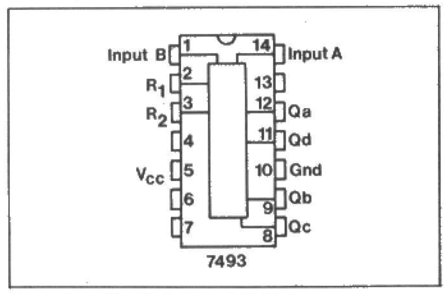


Figure 7. Pin Out of the 7493.

and 11, that is, Qb, Qc and Qd. The final two pins which deserve special mention are pins 2 and 3, labelled R1 and R2. These are 'reset' inputs and if not connected will float high and force the outputs Qa to Qd to remain fixed at logic 0. For the chip to be enabled both these pins must be connected to logic 0. Finally, the logic levels at the outputs can be displayed by connecting an LED to each one, via a 1k current limiting resistor as explained before. An illuminated LED in-

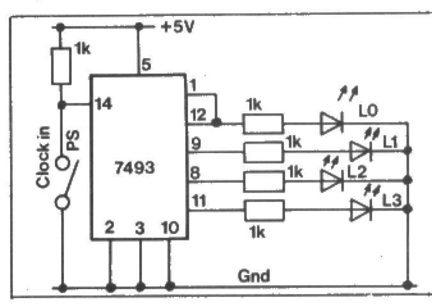


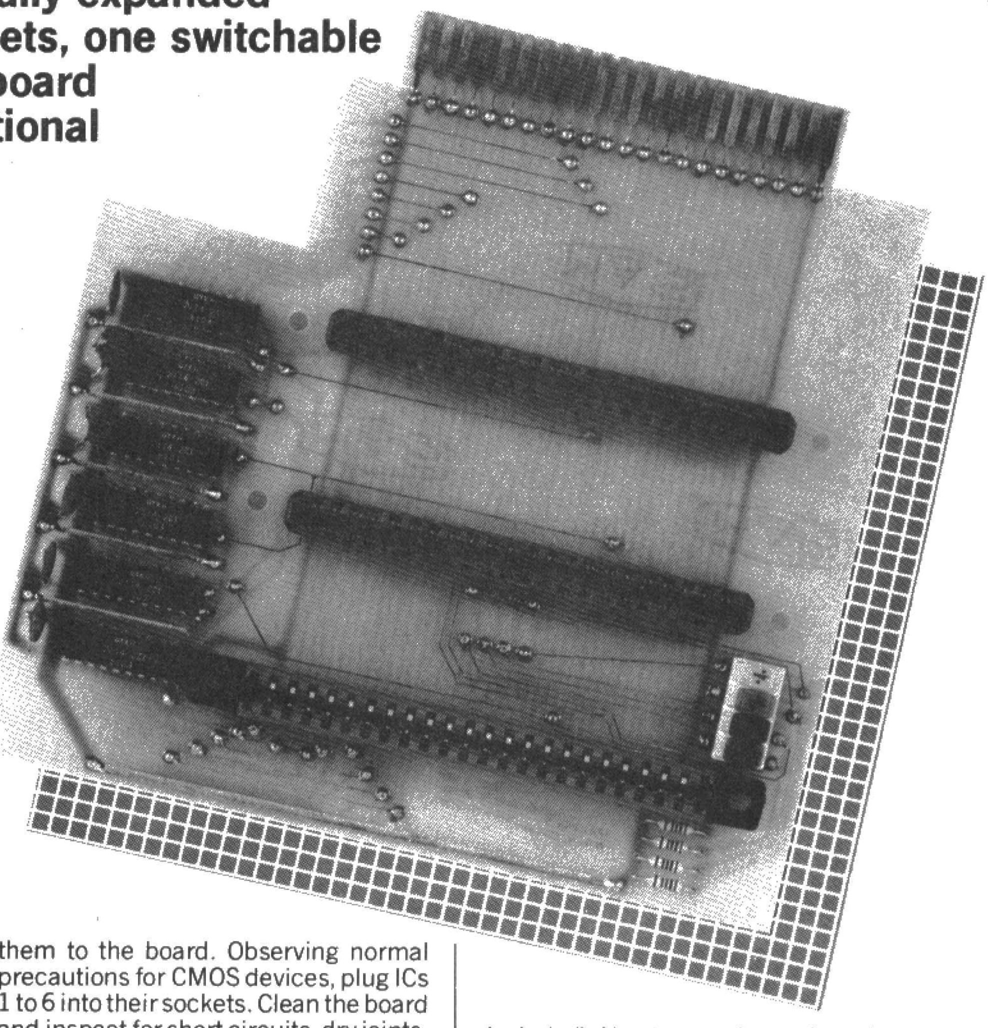
Figure 8. 7493 four bit binary counter.

dicates a logic 1 at that output and an unlit one a logic 0. Figure 8 shows the circuit for the 7493 to operate as a four bit binary counter, using a simple push switch to produce a series of pulses. If the counting sequence starts from 0000 (all LED's out), then it should be possible to verify that the sequence of outputs follows the pattern given earlier in Fig. 2c. Thus this circuit can be used to count a series of up to 16 pulses before returning to zero again. If a larger range is required then two 7493's can be used, with the Qd output of the first one being connected to the Input 'A' of the second one. This would then give eight data line outputs, providing a counting range of 0 to 255 decimal, or 00 to FF hex. as mentioned at the beginning of this article. Next time we shall delve more deeply into counters, and bring together a number of the aspects of digital design into a simple timer project.

VIC20 EXTENDIBOARD

by Mark Brighton

- ★ **Allows the VIC to be fully expanded**
- ★ **Three expansion sockets, one switchable**
- ★ **Optional 3K RAM on board**
- ★ **Cheaper than conventional 3K RAM cartridge**



One problem frequently experienced by the author when programming the VIC20, especially when using hi-res graphics, is lack of memory (within the computer, usually!) This may, of course, be easily overcome by plugging a RAM pack into the expansion socket, but this creates a new problem. No longer is it possible to use a Superexpander/Machine Code Monitor/Forth cartridge etc., because the socket is occupied.

Therefore the subject of this article is an extension board which plugs into the memory expansion connector on the VIC20, and provides three sockets into which any combination of RAM/ROM cartridges may be plugged (within reason, of course, — two games cartridges at once would give your VIC a severe headache).

In addition to these expansion sockets it was considered worthwhile to include a built-in 3K RAM extension on the board, thus freeing a socket from carrying the 3K RAM cartridge. This is optional, however, and may be omitted, if desired, by leaving out ICs 1 to 6 and capacitors 1 to 5 inclusive.

For those who wish to experiment with switching blocks of memory in or out, during initialisation for example, the block select lines on the rear socket are switchable.

Construction

Referring to the circuit diagram and parts list, locate and fit all capacitors, switches, and IC sockets, then solder them to the board. Observing normal precautions for CMOS devices, plug ICs 1 to 6 into their sockets. Clean the board and inspect for short circuits, dry joints, etc.

Testing

Plug the extension board into the memory expansion connector on the rear of the VIC, and switch the computer on. If all is well, the VIC should initialise and display the message '6655 BYTES FREE', (if ICs 1 to 6 are included). Now try entering and running a small BASIC program from the keyboard to check the operation of the 3K RAM extension. Program 1 would be suitable. Lastly, try a game cartridge, or similar, in each of the three sockets of the board in turn. Remember to switch the computer off before attempting to remove or replace a cartridge or the extendiboard.

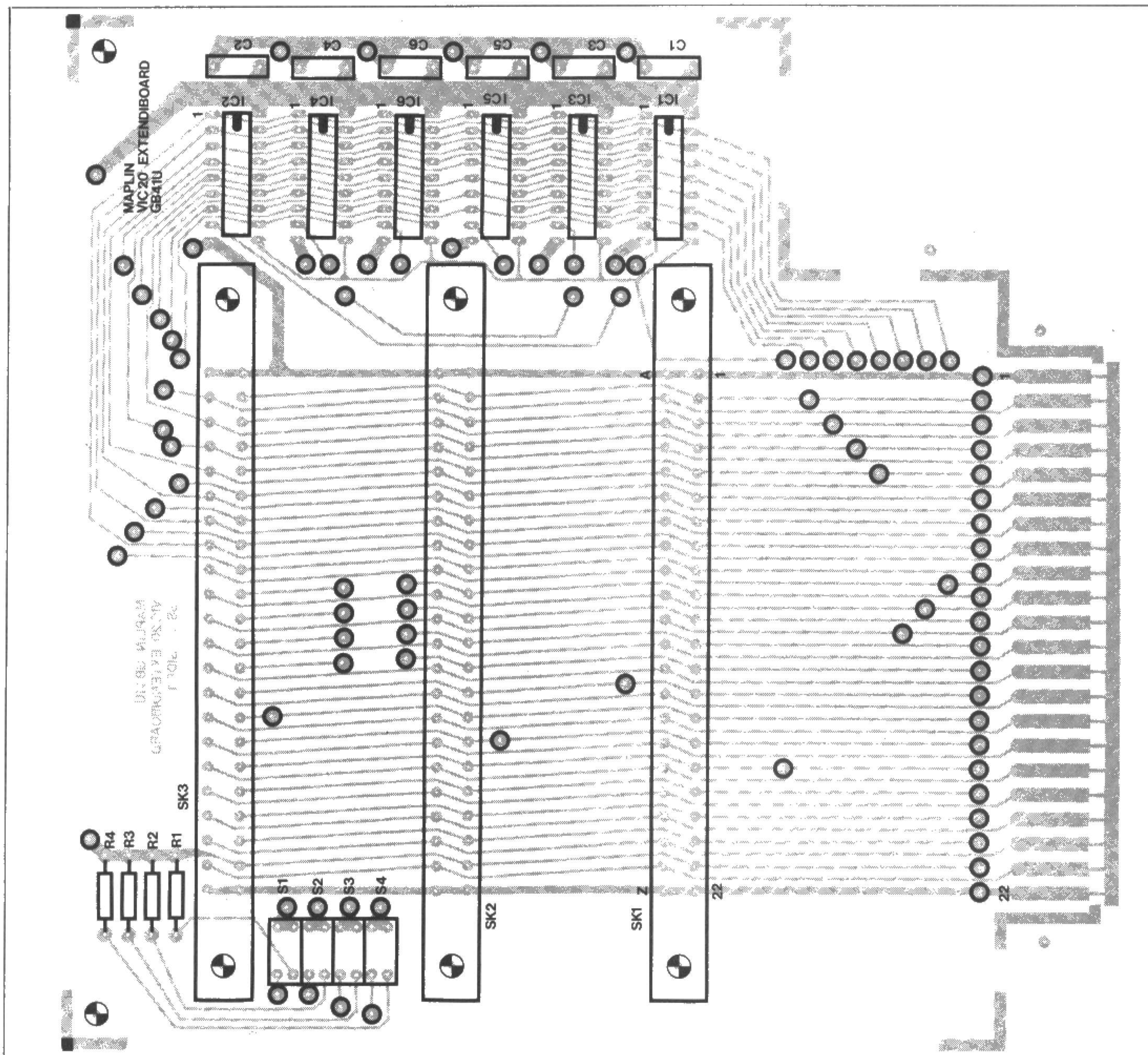


Figure 2. PCB layout.

Usage

As there are many possible uses for an extension board such as this, they could not all be covered in this article. However, I shall attempt to outline a few:

One 16K RAM cartridge and one 8K RAM cartridge, for those who write very long programs or wish to handle large amounts of data. This is the maximum memory extension available to BASIC on the VIC20.

The machine code monitor cartridge is not normally usable in the fully expanded VIC, as its address area lies within the top 8K RAM area. It could, however, be used in place of the 8K RAM cartridge, which still leaves a very considerable area for machine code program storage.

Maplin Talkback, or similar add-ons, plus extra RAM if required, can now be used together. Programs can be written using hi-res graphics, complex sound effects, *and* speech synthesis in BASIC or machine code. Your programming abilities and imagination can come into full play — the possibilities are limitless.

It should be remembered that if 8K or 16K RAM cartridges are used, then the board 3K expansion, or 3K RAM cartridge, are not available for BASIC program storage, due to the way the operating system arranges screen memory during initialisation. This area (decimal 1024 to 4095) is still useful for data storage using PEEK and POKE from BASIC, or may hold machine code to be executed using 'SYS' or 'USR'.

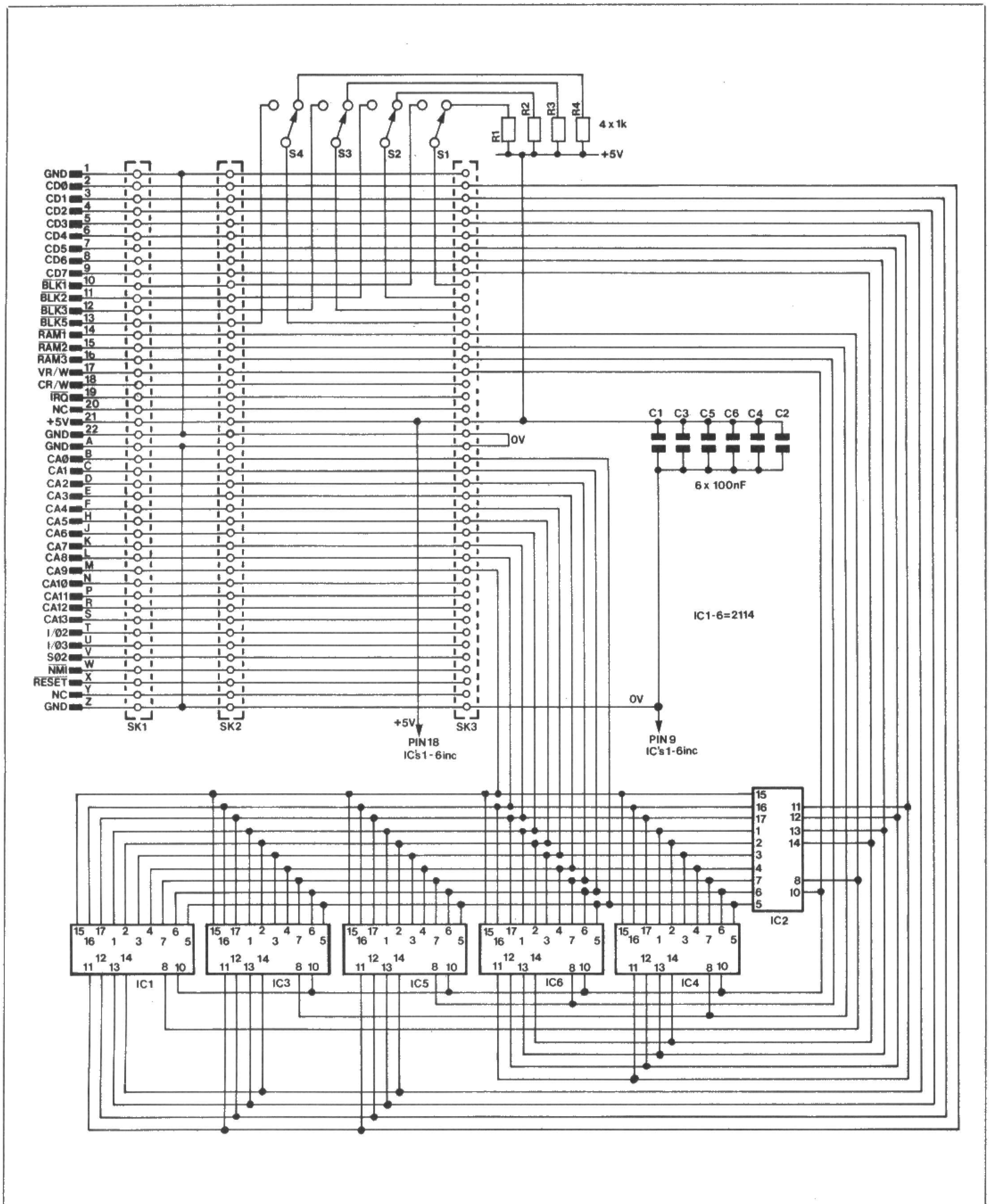


Figure 1. Circuit diagram.

PARTS LIST FOR VIC20 EXTENDIBOARD

Resistors — All 0.4W 1% Metal Film

R1-4 inc.	1k	4 off	(M1K)

Capacitors

C1-6 inc.	100nF polycarbonate	6 off	(WW41U)

Semiconductors

IC1-6 inc.	2114	6 off	(QW12N)

Miscellaneous

S1-4	Switch SPDT Quad		(XX29G)
SKT1-3 inc.	0.156" 2 x 22 Way P.C. Edgecon	3 off	(BK79L)
	VIC20 extendiboard		(GB41U)
	Track pin	2 pkts	(FL82D)

A complete kit of all parts is available.
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MEASUREMENTS IN ELECTRONICS Part One

by Graham Dixey M.I.E.R.E.

Measurements in electronics are as important a part of the hobby (and the profession) as the construction of a circuit itself. Whereas the integrity and reliability of the finished circuit will depend to a large extent upon, for example, the ability to solder and to manipulate components with hand tools, the setting-up, trouble-shooting and perhaps further development will certainly depend upon the successful use of instruments. Invariably the hobbyist, unwittingly or otherwise, will get involved in the servicing of items that he has not actually constructed himself. He is bound to want to 'have a go' when the stereo goes 'on the blink' rather than risk the expense of the local repair shop. Again, in a broad sense, a sound knowledge of measurements, combined with a logical approach, is essential. As an example, the owner of a multimeter will get only the minimum of guidance from the instruction manual supplied with it. This will not, by itself, stop him from making mistakes. By mistakes I do not mean the obvious ones of trying to measure voltage on the current ranges and popping the cut-out, but attempting to use it to measure signals at levels of voltage or impedance or extremes of frequency quite unsuitable to it. Thus measurements, as discussed and explained in this series, is about choosing the right instrument in the first place and then how to get the best out of it. Details of simply constructed items of test-gear will be included, as will details of tests to locate faulty components in circuits. Fault-finding is a form of detective work and as such is a challenge to the technician. It is wrong to think that complex test equipment is always needed to service complex circuits — it is surprising just how much can be done with nothing more than a multimeter. On the other hand, to test to full specification even a fairly simple amplifier requires rather more. This series will deal with both aspects and more besides.

The Right Instrument for the Job

Before considering any instruments, there is one "golden rule" that must be accepted and remembered at all times. It is quite simple, even obvious, and it is that 'the connection of any measuring instrument into a circuit should not influence the circuit itself.'

Measuring Voltages

This is almost certainly the most common measurement likely to be made, so it is a logical starting point. It can be subdivided into two areas — the measurement of direct voltages and the measurement of alternating voltages. We will take the former first.

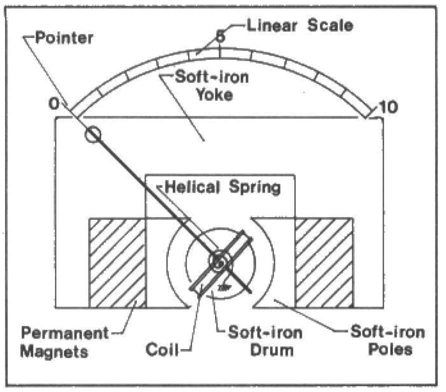


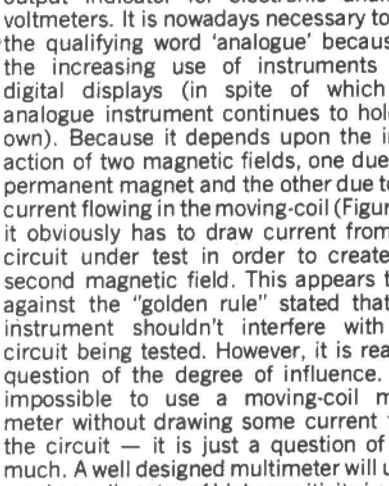
Figure 1. Basic construction of moving-coil meter.

The Moving-coil Meter

This instrument, which depends upon the motor principle, is the basis of the analogue multimeter and is also used as the output indicator for electronic analogue voltmeters. It is nowadays necessary to add the qualifying word 'analogue' because of the increasing use of instruments with digital displays (in spite of which the analogue instrument continues to hold its own). Because it depends upon the interaction of two magnetic fields, one due to a permanent magnet and the other due to the current flowing in the moving-coil (Figure 1), it obviously has to draw current from the circuit under test in order to create the second magnetic field. This appears to go against the "golden rule" stated that the instrument shouldn't interfere with the circuit being tested. However, it is really a question of the degree of influence. It is impossible to use a moving-coil multimeter without drawing some current from the circuit — it is just a question of how much. A well designed multimeter will use a moving-coil meter of high sensitivity i.e. one that draws a very small current, which is typically no more than 50uA for full-scale deflection (f.s.d.) but can be as low as 10uA.

The Mysterious kΩ/V

The intending purchaser of a moving-coil multimeter is faced with a specification which includes, not only details of the ranges covered, but also the sensitivity, which is quoted as so many kΩ/V, 20kΩ/V being typical. Some may find it mysterious that sensitivity should be expressed in such a way, so a short explanation, with reference to Figure 2, may make this clearer. In order to measure voltage at all with a moving-coil meter, a series resistor (the multiplier as it is often called) is added in series with the meter. The purpose of this resistor is to drop the excess voltage since the meter itself requires only a small voltage across it for full-scale deflection. How small this voltage is, can be found from Ohm's law. For a meter of 50u A f.s.d., the coil resistance is usually 2500 ohms, giving a full-scale volt drop of 50.10-6 x 2500 = 125mV i.e. 0.125V. In order to measure 10V full-scale, the series resistor must drop 10-0.125=9.875V. From this, the required value of R can be found, which is 9.875/(50.10-6=197500 ohms. This is the result found in Figure 2, where the derivation is done a little more formally. Now returning to the question of sensitivity, what is the total resistance between the meter terminals in the above example, including the series resistor R? The answer is, of course, 197500 + 2500, which equals 200kΩ. Now if you divide this resistance by the full-scale voltage i.e. 10V, you get the result that 200kΩ/10V=20kΩ/V. You will always get this answer for a meter with a coil of resistance 2500 ohms and 50uA f.s.d. So what this sensitivity figure really means is that the resistance between the meter terminals is equal to the product: 'full-scale voltage selected x kΩ/V'.



$$V_m + V_R = 10V$$
$$V_m = I \times R_m \quad ; \quad V_R = I \times R$$
$$\therefore I.R_m + I.R = 10V$$
$$\therefore R = (10 - I.R_m)/I$$
$$= \frac{50 - (50 \times 10^{-6} \times 2500)}{50 \times 10^{-6}}$$
$$= 197\,500 \text{ ohms}$$

Figure 2. The Mysterious kΩ/V.

For example,

On the 3V f.s.d. range, meter resistance = 3 x 20 = 60kΩ.

On the 10V f.s.d. range, meter resistance = 10 x 20 = 200kΩ.

On the 100V f.s.d. range, meter resistance = 100 x 20 = 2MΩ.

This shows quite clearly that the resistance between the meter terminals depends upon the range selected, the higher the range the higher the meter resistance. Unfortunately, in electronics we are more likely to be measuring small voltages than large ones, so the meter resistance is often fairly low. The situation can be improved by using a meter of higher sensitivity e.g. 100kΩ/V, which gives a five-fold increase in meter resistance; the price that you pay is that the meter movement is much more delicate and, hence, more prone to accidental damage.

A Matter of Loading

A perfectly reasonable question to ask is 'just why is the terminal resistance of the meter so important?' The answer lies in the "golden rule" stated earlier — the meter must not influence the circuit. Taking two examples to illustrate the point, first look at Figure 3. Two resistors, R1 and R2, are in

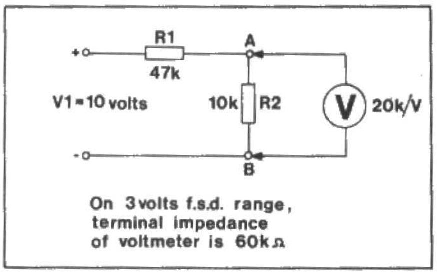
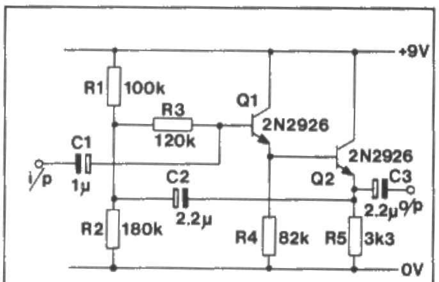


Figure 3. Loading Effect of Voltmeter.

series, with a total of 10V across them. It is required to measure the voltage across R2, whose value is 10kΩ. Using a voltmeter of sensitivity 20kΩ/V, gives a meter resistance of 60kΩ on the 3V f.s.d. range. This means that when the voltmeter is connected into circuit its effect is just as if a 60kΩ resistor had been connected across R2, which gives a total effective resistance between points A and B of (60 x 10)/(60 + 10) = 8.57kΩ. The voltmeter will read 10 x 8.57/(47 + 8.57) = 1.54V. This can be compared with the 'actual' voltage which would exist across R2 in the absence of the voltmeter. This equals 10 x 10/(47 + 10) = 1.75V.

The 'absolute error' is the difference between these two values, which is -0.21V (the minus sign indicates that the meter is reading low). As a percentage of the true value it is -(0.21/1.75) x 100%, which is -12%.

This example indicates that the connection of a meter into a circuit will cause an error, which may or may not be significant. The figure of 12% in the previous example is probably not as bad as it sounds, especially considering the tolerances that must be placed on test voltages in circuits in practice. Usually if one is looking for a fault, the departure from the true voltage will be much greater than this. Also, in many circuits, the value of R2 may well be rather less than 10k in its effective value, giving a lower error than the one calculated in this example. One can conclude from this that provided the meter resistance is very much greater than the resistance across which it is connected, then no appreciable error will occur; this is often the case in practice. However, one should always be on one's guard for exceptional examples, and the second case in Figure 4 illustrates this. This circuit shows a Darlington-connected emitter follower, whose object is to present a high input impedance to the signal input. It is required to measure the d.c. potentials at the collector, base and emitter of each transistor, with respect to 0V. The results of these measurements are shown with (i) a d.c. moving-coil voltmeter, sensitivity 20 KΩ/V on the 10V range (terminal resistance therefore equals 200kΩ.), (ii) a d.c. electronic



Meter	Voltages Q1 c	b	e	Q2 c	b	e
m c meter	9	2.86	4.86	9	4.86	4.33
d.c. E.V.M.	9	5.3	4.86	9	4.86	4.2

Figure 4. A More Severe Case of Loading.

voltmeter of input resistance 10MΩ. The base potential of Q1 is quite wrong as measured by the moving-coil instrument; the base bias appears to be -2V! The measurement made with the d.c. electronic meter, which has a very much higher input impedance, shows a much more likely state of affairs with a forward bias of 5.3-4.86= 0.5V. The errors arise, of course, because the terminal resistance of the first meter is very much lower than the effective resistance produced by the Darlington arrangement. This circuit actually gives an input impedance of just over 5MΩ. Summing up, for most cases the moving-coil instrument, provided that its sensitivity is at least 20kΩ/V, will be quite suitable for measuring a wide range of direct voltages. Very high voltages are catered for by a special high-voltage probe, such as is used in measuring the E.H.T. voltages in T.V. receivers.

The limitations arise in two main cases:
(i) When the circuit impedance is high.
(ii) When the d.c. to be measured is verv small e.g. less than 0.5V, since the lowest range on this type of instrument is usually about 3V f.s.d. For best accuracy, readings should never be taken too low down on the scale, say below 20% f.s.d. Now we can consider the measurement of alternating voltages.

Meters for a.c.

The situation for a.c. is more complex; there are four factors to consider:

(i) The circuit impedance — similar consideration to the d.c. case.
(ii) The waveform of the a.c.
(iii) The frequency of the .a.c.
(iv) The amplitude of the a.c.

Take the circuit impedance first. The same rules apply as before. Unfortunately they are not always so easy to meet, certainly not with the moving-coil multimeter. The kΩ/V rears its head again and, in the a.c. case, is found to be very much less than the usual 20kΩ/V of the d.c. case as low as 1kΩ/V, even 100Ω/V is much more likely. This happens because of the need to include a rectifier on the a.c. ranges in order to read a.c. at all. As a result, the moving-coil/rectifier combination is quite unsuitable for any measurements other than those where there is enough power available to drive the meter. This implies that it can only really be used for measuring mains voltages rather than signal voltages. This limits it to measurements of the voltages across transformer primary and secondary windings, motors, solenoids, thermostats, etc. Having, therefore, dismissed the multimeter from a.c. signal measurements on the grounds of (i) impedance, there seems little point in considering (ii), (iii) and (iv). We pass on, therefore, to a more suitable instrument without more ado.

The a.c. Electronic Voltmeter

This instrument simultaneously satisfies all the requirements previously mentioned. This it does by electronic amplification or attenuation of the signal, such that a high impedance, usually more or less constant on all ranges, of several MΩ is presented to the signal. At the same time, the range selector ensures that small signals (down to uV) are amplified and large signals (up to several hundred volts) are attenuated to a common level to drive a rectifier/moving coil meter. In this case, the presence of the rectifier is of no importance, since it is isolated by the amplifier from the test circuit. Also, since an amplifier can be designed to have more or less the bandwidth you require, signals covering a wide frequency range, usually up to several MHz, can be measured. This leaves one unresolved question, that of waveform. Such an electronic voltmeter (E.V.M.) may have the abbreviation R.M.S. on its scale. But, if it is a little more honest it might actually say 'Mean-sensing R.M.S. calibrated' and this statement immediately imposes a limitation on the waveform that can be meaured. In fact, it limits it to one only, the sinewave! The limitation arises because the rectifier/moving-coil combination responds to the mean or average value of 'any' waveform. Unfortunately, this average value is rarely of any interest — what is usually wanted is the R.M.S. value. As it happens, this is related to the average value by a constant, known as the form factor, which is 1.11 for a sinewave. This means that when measuring sinewaves, the R.M.S. value = average value x 1.11 relation can be used. However, rather than leave the user to perform this calculation, it is incorporated into the scaling of the voltmeter scale, which immediately restricts the use of the instrument for sinewaves, since the form factor has a different value for other waveforms. Thus, a reading on any other waveform than a sinewave is quite meaningless — an important point to be aware of.

Fortunately, most measurements will be made on sinewaves so the restriction is not too serious. Obviously if we need to measure the amplitude of, say, a square wave or a triangular wave, we shall have to use some other instrument, of which more anon.

Measuring Current

Again, of course, there are d.c. and a.c. cases to consider. The measurement of direct current generally presents no problem. All that one must remember is that the meter must be connected in 'series' with the current. This implies breaking the

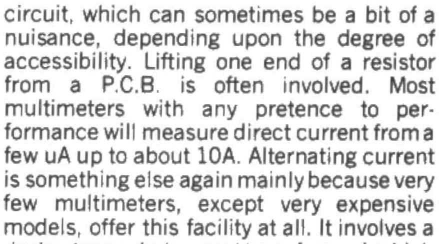


Figure 5. Indirect Measurement of Small Current.

circuit, which can sometimes be a bit of a nuisance, depending upon the degree of accessibility. Lifting one end of a resistor from a P.C.B. is often involved. Most multimeters with any pretence to performance will measure direct current from a few uA up to about 10A. Alternating current is something else again mainly because very few multimeters, except very expensive models, offer this facility at all. It involves a device termed a 'current transformer', which most manufacturers would rather leave out. There is a good reason for it. The number of times that you need to measure an alternating current are not all that great, and when you do need to, the chances are it will be a small signal current, well below the current ranges available on a multimeter. So how does one meet this requirement? One answer is to use an indirect method which involves the use of an E.V.M. and a bit of simple arithmetic. Now see Figure 5. The bipolar transistor, being a current-operated device, has an alternating current, due to the

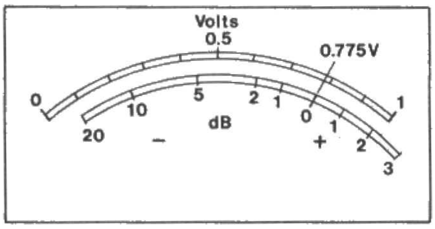


Figure 6. Voltage and decibel (dB) Scales.

signal, flowing in its base lead. With the exception of power stages, this current is usually no more than a few uA and is, therefore, incapable of being measured readily by a direct meter measurement. The answer is to convert this current to a voltage, which can then be measured easily using an E.V.M. A resistor is wired in series with the current to produce a volt drop equal to I x R, where I is the signal current and R the resistor in question. As long as the resistor does not change the current significantly the method works well.

The dB Scale

On electronic voltmeters of the analogue type (and also on many multimeters) will be found a scale of the type shown in Figure 6. The decibel (dB) is a power ratio such that the number of dB that expresses the ratio = 10log(P2/P1), but it may also be used for the ratio of two voltages or two currents with one reservation. That reservation is that the two resistances across which the two voltages appear, or through which the two currents flow, are equal. In which case we get:

Ratio in dB = 20log(V2/V1) for voltages
or 20log(I2/I1) for currents

Using these formulae it is easy to calculate the corresponding decibel ratio. For example, if the two voltages are V1 = 25mV; V2 = 125mV, perhaps at the input and output of an amplifier, then the ratio in dB = 20log(125/25),
= 20log5,
= 14dB.

By measuring the output voltage (V2) of an amplifier produced by a constant input voltage (e.g. V1 = 25mV) over a range of frequency, it is possible to plot the gain/frequency response of an amplifier. However, the same response graph can be produced without any calculations at all, just by using the dB scale. This is done by adjusting the input to the amplifier so that the meter at the output reads 0dB at some reference frequency (say 1kHz); then at all other frequencies the 'relative response' in dB is read directly off the dB scale. One then gets 'relative' gain as opposed to 'absolute' gain obtained by the calculation method. Often this is all that is needed. The two scales are shown for comparison in Figure 7. This question of the decibel scale will be dealt with at greater length later on in the series.

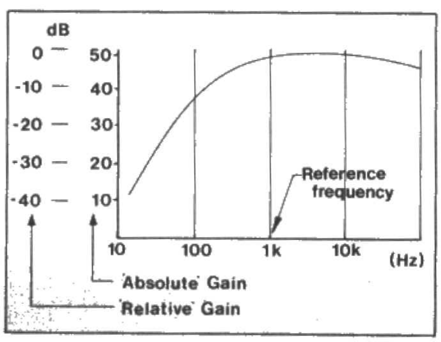


Figure 7. The dB — Absolute and Relative Gain.

Digital Multimeters

So far no mention has been made of the role of the digital multimeter. There are good reasons for this. In spite of the increasing use of digital read-outs generally, many feel a preference for the analogue type of presentation. Further, as far as hobbyists are concerned, price must be a consideration and a moving-coil multimeter, of adequate performance, still undercuts the price of a digital instrument. Nevertheless, one should consider the case for or against the digital meter. The first point for comparison is the display itself. Its great asset is that it is unambiguous; usually the value is read as a decimal number, including decimal places — though sometimes a multiplier has to be applied. The chances of making an error in readings are fairly small. However, the instrument works best for steady readings. if the value is varying continuously, it is often not too easy to assess its mean value — an operation which can be done quite easily with a pointer type display. As far as terminal impedance and frequency response are concerned, the input impedance is high: 10MΩ on d.c. and 1MΩ on a.c. are possible. The frequency response is nowhere near that of an analogue E.V.M., 40Hz-20kHz being an example. However, the high input impedance and its ability to measure down to a few mV means that at least it can be used to measure audio-frequency signals, which the analogue multimeter cannot do. In the end it comes down to one's personal preference for the display and the depth of one's pocket.

An Application of the a.c. Voltmeter — Phasing of Transformer Windings

Having more or less shot down the a.c. voltage ranges of the analogue multimeter for electronic work, on the grounds of terminal impedance alone, it is worth taking one example of its possible use, apart from the simple measurement of mains voltages. After all, we shall be dealing with many uses of the d.c. voltage ranges. Often mains transformers have dual secondary windings which can be connected in series (to give increased voltage) or in parallel (to give increased current). These secondaries may be identified as 0-20V; 0-20V, for example. If so marked, then connecting 0 to 0; 20 to 20 gives parallel connection, while connecting 0-20 'to' 0-20 gives series operation. There is no problem as long as the windings are clearly marked. If they are not, then provided that the individual secondaries have been identified, a simple phasing test can be used to establish how to connect them up without placing any short-circuits on the transformer. The principle is shown in Figure 8. Whether series or parallel connection is ultimately required, connect the separate windings are shown, i.e. a link between the end of one winding and either end of the other. An a.c. voltmeter connected between the free ends of the windings will indicate the algebraic sum of the secondary windings, and this will depend upon the phase of one winding with respect to the other. Therefore, the voltmeter will read either 'zero' (windings in opposition) or double the individual secondary voltage, on the assumption that the windings are identical. If the latter is the case, then the link from B to C is correct for series operation. Then for parallel operation, A goes to C, and B goes to D. But, if the former is the case then reverse a winding e.g. link A to C for series operation (output between B and D) or link B to C, A to D for parallel operation.

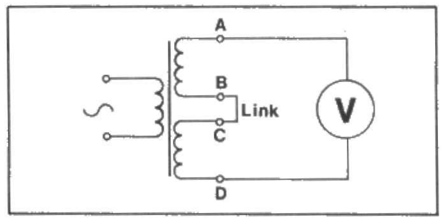


Figure 8. Checking Transformer Phasing with a.c. Voltmeter.

A Simple Regulated Power Supply

As part of this series, each instalment will include details (excluding layout and construction usually) of a simple but useful piece of test equipment. To start the ball rolling, the first offering is a simple variable-voltage power supply (Figure 9), on a single chip, the L200. This will give an output variable between +3V and +20V approximately at about 450mA, with automatic overload protection. If a small moving-coil voltmeter can be afforded, this can produce a very professional style power supply at reasonable cost.

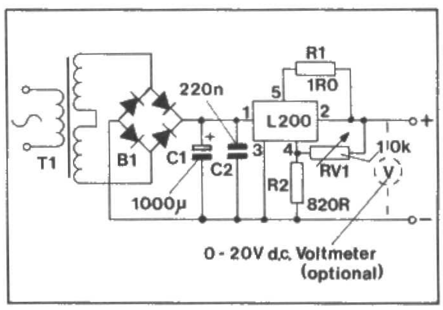
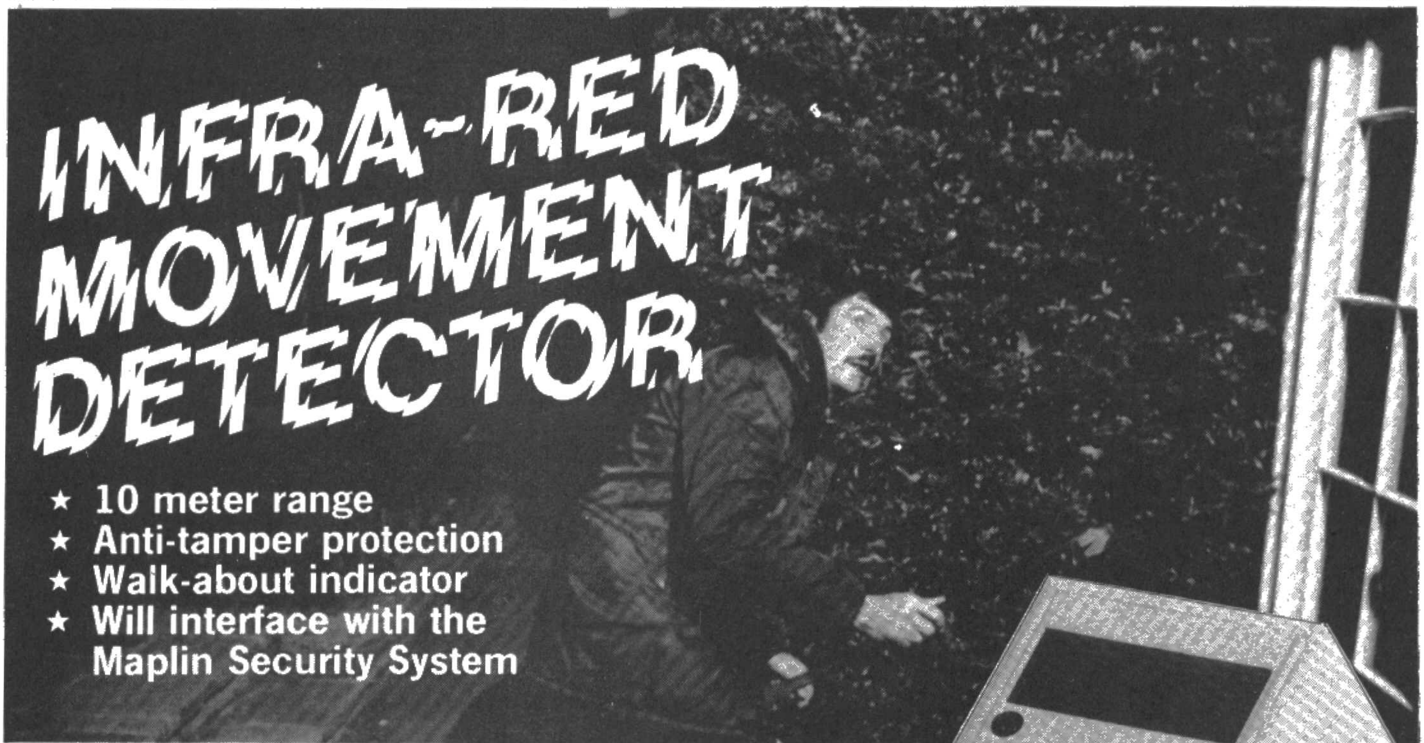


Figure 9. A +3 to +20 Volt Variable Regulated Power Supply.

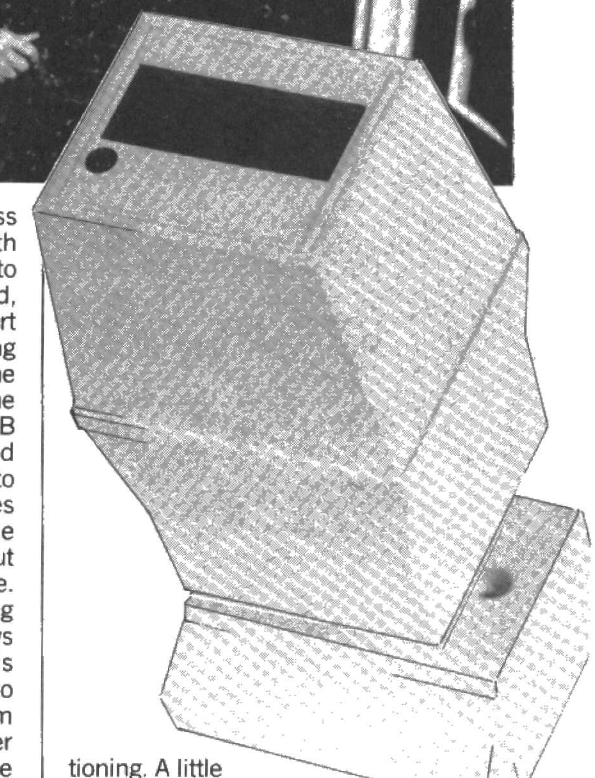
PARTS LIST FOR POWER SUPPLY

Resistors		
R1	3W wirewound	(W1R)
R2	820R ½W 5% carbon	(S820R)
RV1	10k linear pot.	(FW02C)
Capacitors		
C1	1000u 25V elect	(FB83E)
C2	220n polyester	(BX78K)
Miscellaneous		
IC1	L200 regulator	(YY74R)
B1	W01 bridge rectifier	(QL38R)
T1	Mains transformer Secs. 0-9V; 0-9V @ 500mA, series connected.	(WB11M)

INFRA-RED MOVEMENT DETECTOR



- ★ 10 meter range
- ★ Anti-tamper protection
- ★ Walk-about indicator
- ★ Will interface with the Maplin Security System



by Dave Goodman

The ASD 10/15 is an infra-red pyro-electric movement sensor which requires a 10.7 to 16V (nom 12V 20 mA) supply. The module has adjustable sensitivity for coverage up to 12 metres distance and 2 metres downward deflection, allowing a variety of mounting positions. The fixing base has a ball/socket arrangement with the sensing head, giving 120 degrees rotational movement for optimum positioning. Kits contain all electronics, silicon window (pre-mounted) and plastic modular case enabling a completely finished unit to be built.

Construction

Refer to the main parts list for component designation. Figure 2 shows all component positions and will need to be referred to for assembly details. Begin construction by fitting resistors R1 to R21. Each component lead will need to be bent as close as possible to the resistor body before insertion, due to the PCB hole spacing being somewhat narrow. Mount the vertical preset RV1 and the diode D2. IC 1 can also be mounted at this stage. Solder these components carefully in place then remove excess wire ends. Fit TR1 to TR4, and both regulators, followed by capacitors C1 to C8. Tantalum capacitors are polarised, so be sure to fit C1 to C6 correctly. Insert relay RLA which has four terminals along one side and two along the other. If the relay body has a white bar printed at one end, then match this with the PCB overlay to ensure correct fitting. Bend both leads on the L.E.D. at right angles to the body and insert them into the holes marked A and K (see Figure 8). Push the L.E.D. down onto the PCB so that about 5mm is protruding over the front edge. Solder the L.E.D. and other remaining components into place (Figure 3 shows mounting details for the diode, which is bent into a "U" shape for insertion into the PCB). Tilt this component away from RV1 wiper to allow for adjustment later on. A 10 way socket SKT1 clips over the edge of the PCB and is positioned at about 30 degrees so that both locating guides fit under the PCB. Straighten the socket and all 10 terminals should slide into the PCB. It is not necessary to use undue force for this although if problems are encountered, try bending the terminals outward slightly before positioning. A little more care is needed to fit I.R.D. 1. This pyro-electric sensor has a small window on top, which *must not* be touched, otherwise grease deposited from the skin will dramatically affect the sensitivity of the unit. Hold the sensor by the sides and fit it in place above IC1. Figure 8 shows lead desig-

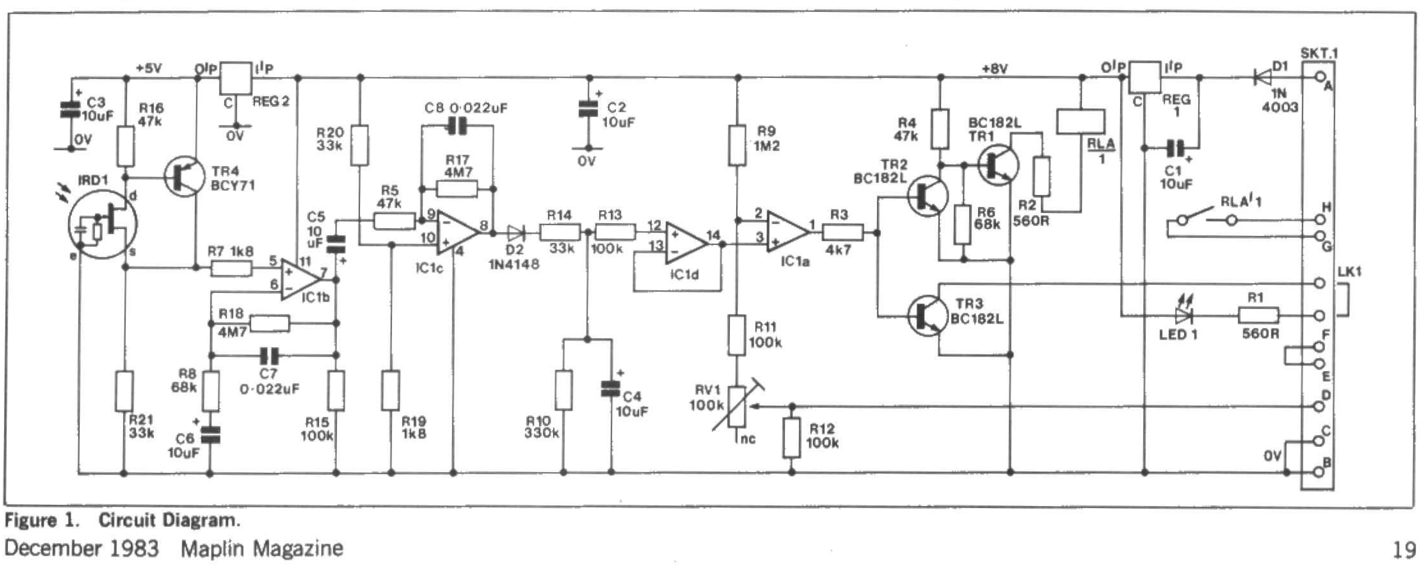


Figure 1. Circuit Diagram.

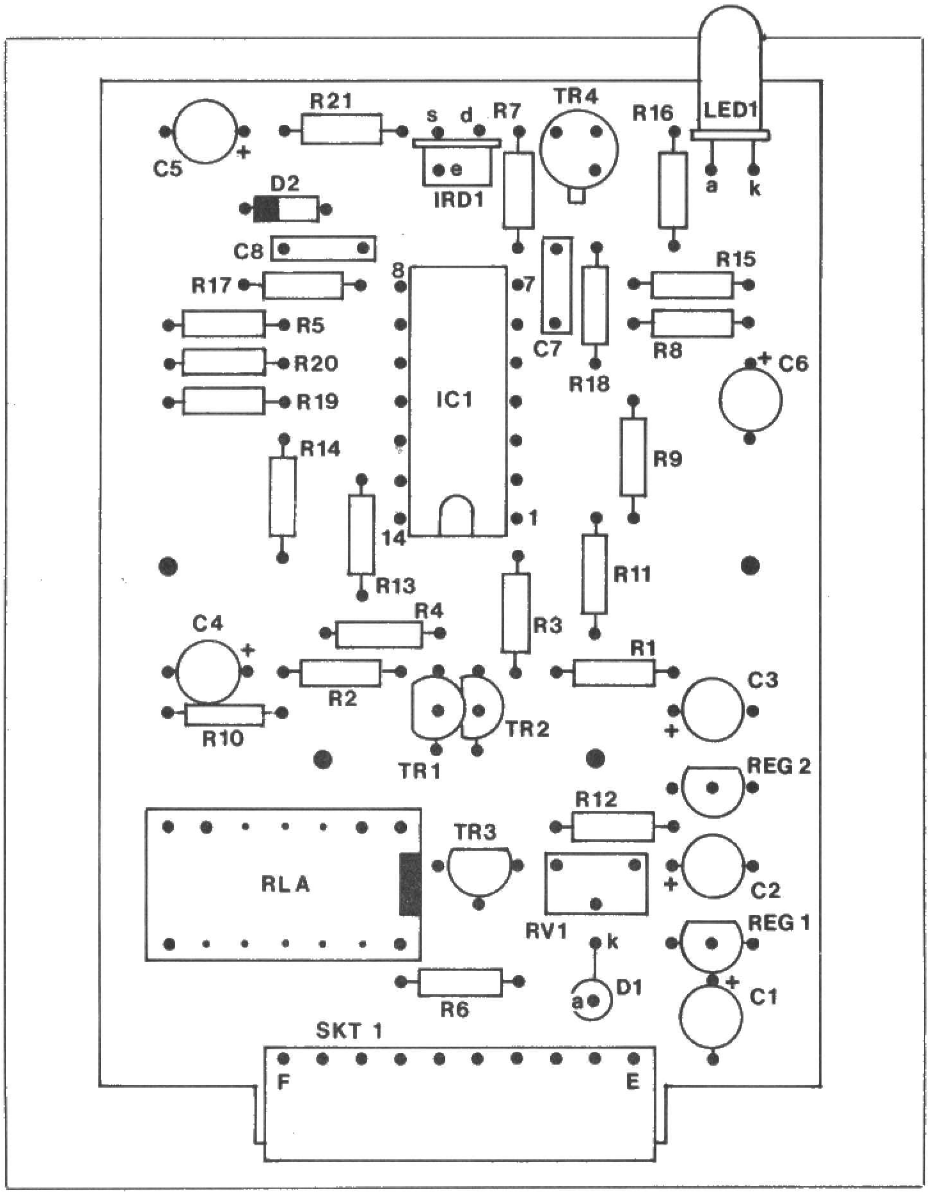
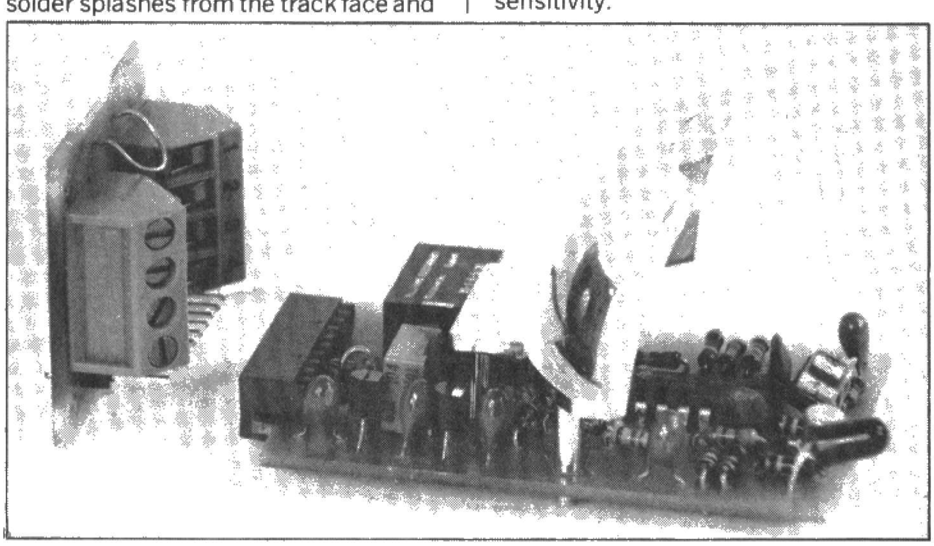


Figure 2. Overlay Main PCB.

nations which also appear on the overlay and Figure 5 gives mounting details. Keep I.R.D. 1 base 8mm above the PCB and solder the leads in place. This done, bend the sensor head 60 degrees from the board as shown. Ensure that the Drain, Source and Envelope leads are not shorting together and that TR4's case (Collector) is not touching the case tag of I.R.D. 1. Check that all joints are soldered, remove wire, flux or any solder splashes from the track face and make a close inspection of the work so far. Finally fit the plastic silvered mirror into the holes on each side of the PCB. Try not to touch the inside surface for reasons previously covered. A small spot of cyanoacrylate glue applied to each leg will hold the mirror in place and prevent movement. As a guide the sensor should be pointing centrally between the 3rd large and 5th small facet of the reflector for maximum sensitivity.



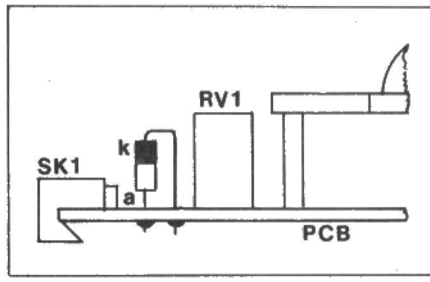


Figure 3. Mounting Diagram.

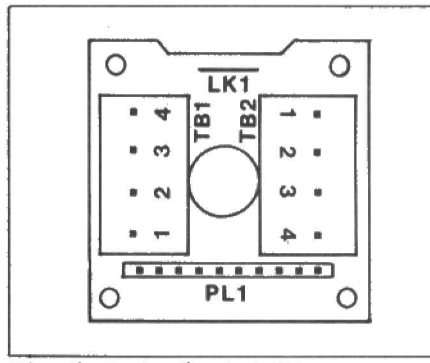


Figure 4. Overlay, Terminal PCB.

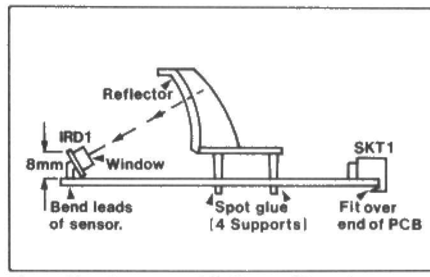


Figure 5. Sensor and Reflector Mounting.

Terminal PCB Construction

Figures 4 and 7 show the mounting details. Both terminal connecting blocks TB1 and TB2 are inserted with their screw heads facing outwards, and the connector side facing inward. Fit the wire link in position LK 1 allowing enough slack to be able to cut it if needed later on. Finally, insert 10 way vertical plug PL 1, the short terminal ends go into the PCB. Solder all components into position.

Case Assembly

The case comes in four sections (Figure 6) along with various pieces of hardware. The "dumbell" shaped gymbal has a small ball end and a large ball end. Insert the small end from inside of section B, the large ball end will prevent it from dropping through. Place one of the steel plates over the ball and secure it by inserting two Allen screws from the outside with two nuts and washers from the inside. Tighten the screws until the gymbal can be moved, but is not sloppy. Fit section A over the small ball end, slip two plastic collets around the shaft and press them down into the moulding. As with section B, position a steel plate over the gymbal, and insert two Allen screws from the outside and two nuts/washers from the inside. Tighten to requirements. Section C slides over section B, two guide runners ensure that this moulding can only be fitted one way around. Both sections C and D contain

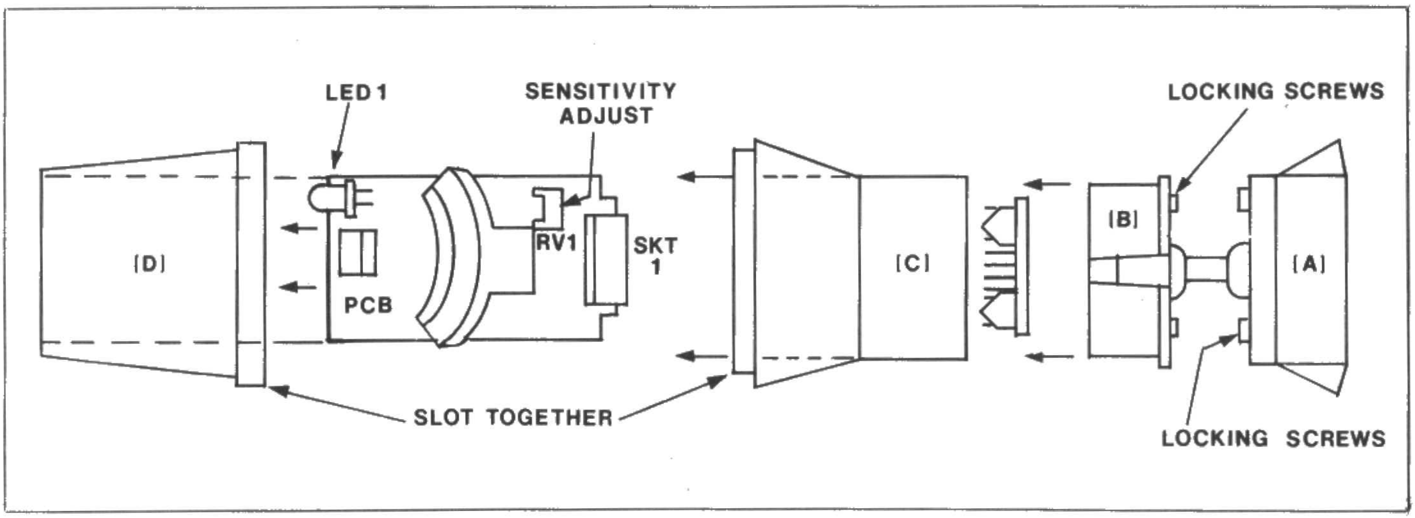


Figure 6. Case and PCB Assembly.

guides for holding the PCB in place. Section D is fitted with a silicon window which is very fragile and easily broken, on no account should it be pressed. Care must be exercised when fitting this section!

PCB Mounting

The small terminal PCB fits into section B (Figure 7). One side of the board is shaped to accommodate a guide as shown, and the PCB must be fitted accordingly, using four self-tapping screws in each corner. Clip section C into position and insert the main PCB which should be held tightly by both guides and PL1/SKT1. Note that SKT1 does not sit hard up against PL1 and a gap of around 2mm is normal. Front section D can now be offered up to the PCB and with its guides correctly positioned, pushed home. If required later a small spot of glue could be applied to the top edge of both sections to keep them from coming apart in use. Providing that LED 1 has been correctly formed, it should just protrude through the front panel, so do not forget to set the angle before insertion.

Testing and Operation

Remove sections C and D and the main PCB if previously fitted. A 12 volt power source will be needed and is wired +12V to terminal A (1) and 0V to B (2) on TB 1 (figures 4 and 7). Use a suitable cable, such as extra flex, which is thin enough to be threaded through the drilled hole in the gymbal. Plug the PCB onto PL 1 and apply power. After several seconds "warming-up" time, LED 1 should turn on accompanied by a quiet click from RLA 1. Point the reflector away from yourself and wait until the LED turns off. It must be appreciated that the unit will not function correctly out of its case, due to saturation of I.R.D. 1, but an indication of operation can still be given by moving a hand over the reflector to bring on LED 1. The trigger threshold control, RV 1, can now be set clockwise to increase or anti-clockwise to decrease sensitivity, but cannot be easily adjusted "in situ". The PCB will have to be unplugged to do this and then re-fitted.

In operation, I.R.D. 1 detects minute

Infra Red Detector *Continued on page 23*

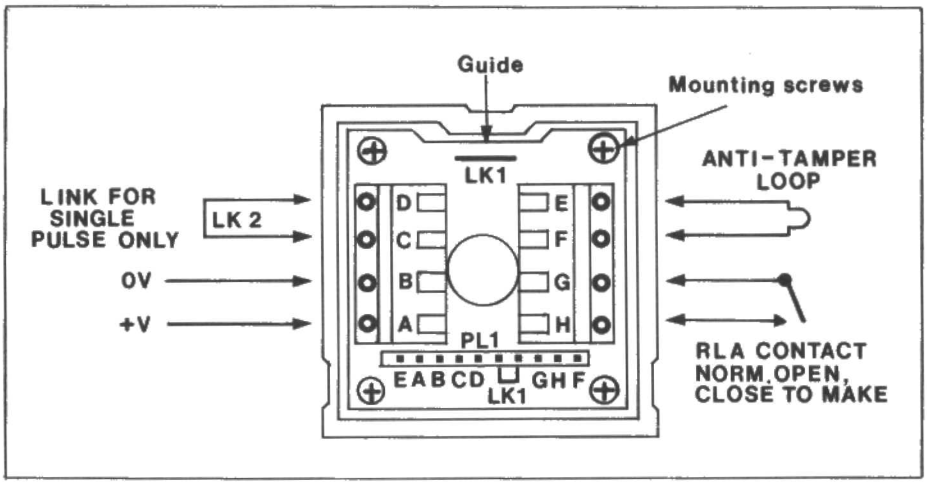


Figure 7. Terminal PCB Assembly.

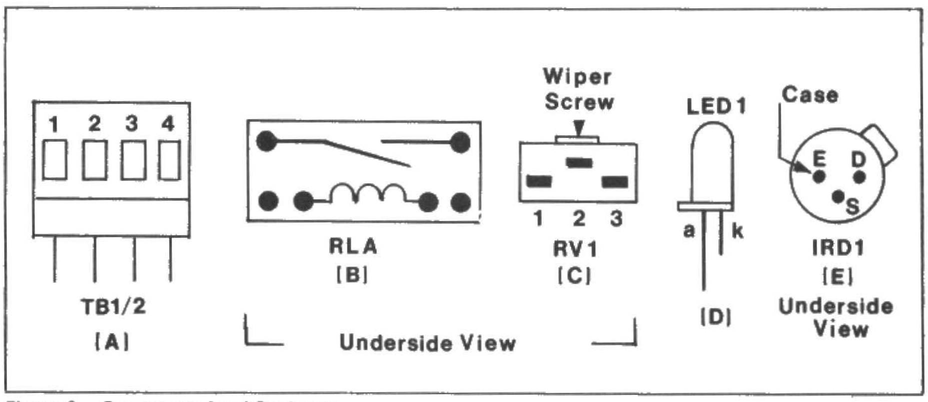
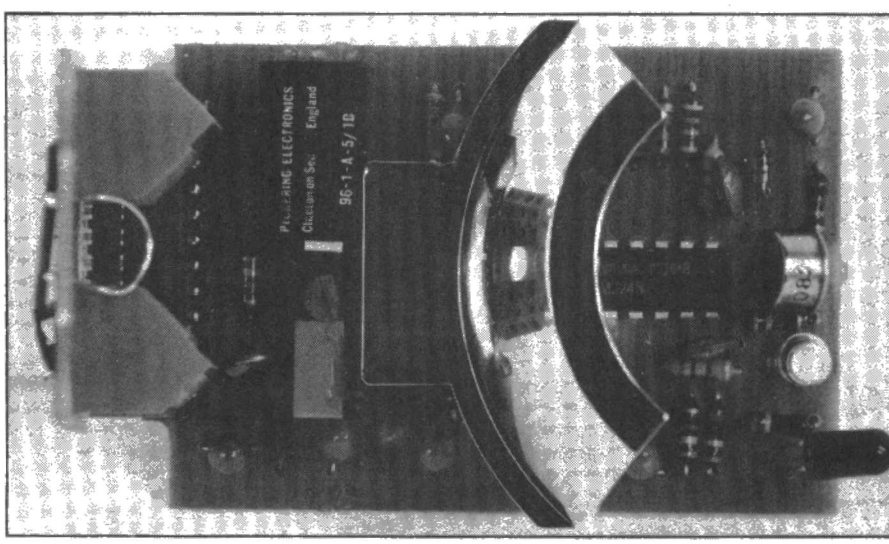


Figure 8. Component Lead Designation.



RS232/TTL CONVERTER

by Dave Goodman

★ Converts 5V TTL to RS232, or vice versa
★ Makes modem use possible on all micros
★ Simple to construct

The current crop of low price home micro-computers has created a large market for peripheral devices, designed to expand the capabilities of these machines. Telephone links, via modems, make intercommunication between micros possible by using the RS232 standard, but unfortunately not all micros have the necessary +/- 12V levels available for data transmission. A method of converting 5V TTL signals to RS232 levels (or vice versa) is needed, and the converter module does just this.

Description

Regulator 1 produces +5V from the +9 to +12V input pin 1, to supply IC2. Regulator 2, which has its common input referenced to +5V, develops approximately a +10V output (dependent on the connected supply). IC1 generates a voltage, exactly opposite to its supply voltage, across C4; this being approx. -10V. Both +/-10V are present at the output stage TR1.

TTL signals are input at pin 3, and inverted by IC2. A second inverter reverts the signal back to the original and both outputs can be selected by S2. TR2 buffers the 5V signal which drives TR1 and outputs on pin 6. RS232 signals on pin 5 have negative voltages removed by D2, and R7 and D3 clamp the positive signals to +5V maximum. Two inverters then connect both input signals to S1 and output on pin 4.

Construction

Bend the leads and insert resistors R1 to R9, D1 to D3. Note that D3 is a zener, and will be a different colour. Fit the black band end to the white bar on the legend. Insert IC1, 2 and TR1,2. Regs 1 and 2 look similar to the transistors, so read the case markings carefully. Finally, fit C1 to C4, S1 and 2, and the 7 vero pins. Both switches may be inserted either way round, but C1, 2 and 4 must be fitted according to the legend. Carefully solder all components to the track, then cut excess leads and clean flux, etc, off the PCB. Inspect all components and joints before proceeding.

Testing

Connect the +12V supply to pin 1, and OV to pin 2. Place a voltmeter across pin 6 and OV, and set S1 and S2 to 'NORM'. Switch on the supply, and you should read approximately +10V. By connecting a length of wire to OV and touching input pin 3 the output should swing from +10V to -10V. Set S2 to 'INV' and repeat; this time the output should swing from -10V to +10V. Set S1 to 'NORM'.

Remove your meter from pin 6, and reconnect between OV and pin 4. The reading should be low, around +100mV. Remove the test wire from OV

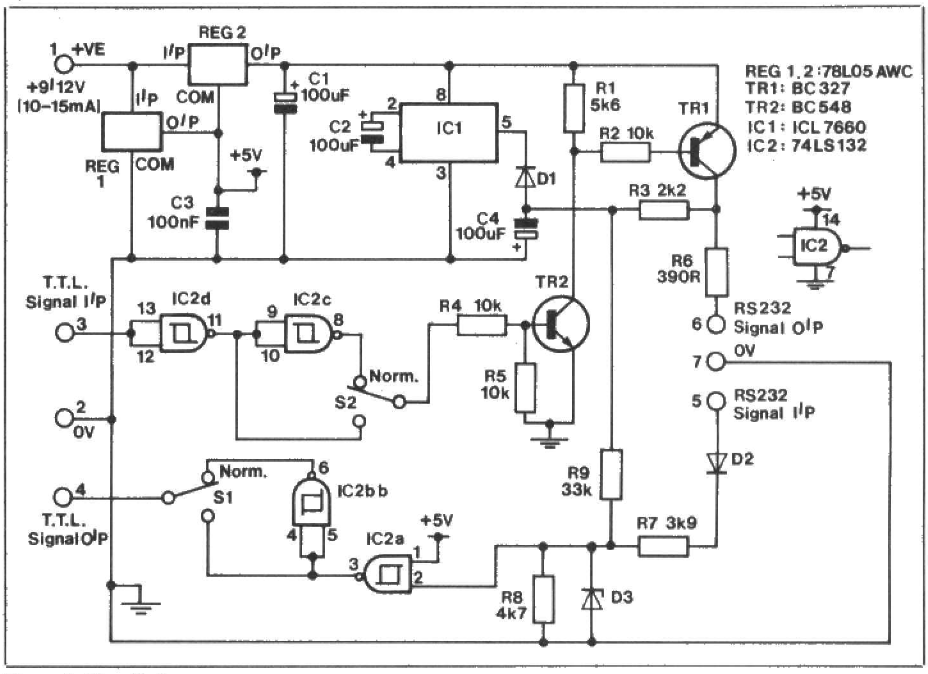
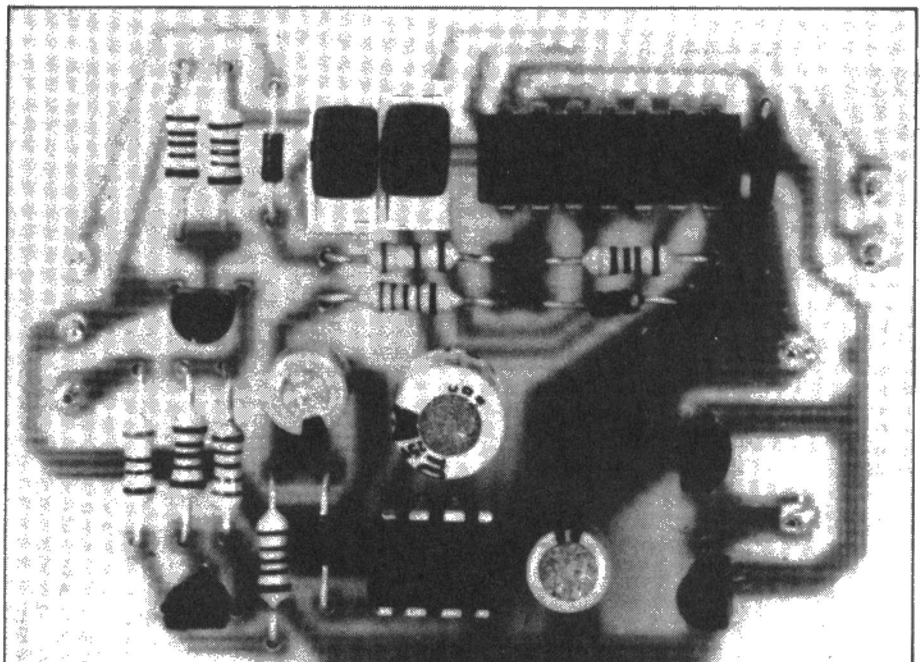


Figure 1. Circuit diagram



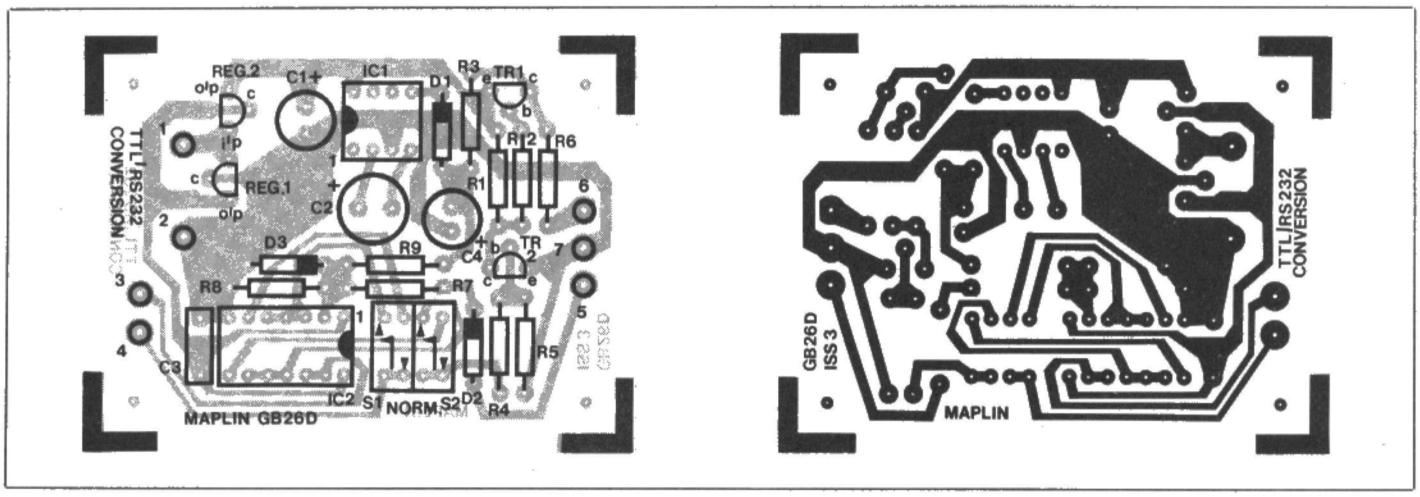


Figure 2. PCB layout and overlay

and pin 3, and connect it to +12V (pin 1). Touch the wire to pin 5 and the output should swing up to +4V. Operate S1 and the meter should read +4V. Touching the test wire to pin 5 again will produce a swing from +4V down to +100mV. Return S1 to 'NORM' position. If all is well the module is ready for use. Connect your computer TTL signal output to pin 3 and TTL signal input to pin 4. The outgoing RS232 line connects to pin 6 and the incoming RS232 line connects to pin 5. Pin 7 can be used as an OV reference or a screen, if required.

PARTS LIST FOR TTL/RS232 CONVERSION

Resistors - All 0.4W 1% metal film unless specified			
R1	5k6		M5K6
R2,4,5	10k	(3 off)	M10K
R3	2k2		M2K2
R6	390R		M390R
R7	3k9		M3K9
R8	4k7		M4K7
R9	33k		M33K
Capacitors			
C1,4	100uF 10V P.C. electrolytic	(2 off)	FF10L
C2	100uF 25V, P.C. electrolytic		FF11M
C3	100nF Disc		BX03D
Semiconductors			
D1,2	1N4148	(2 off)	QL80B
D3	BZY88C4V7		QH06G
TR1	BC327		QB66W
TR2	BC548		QB73Q
REG1,2	78L05AWC	(2 off)	QL26D
IC1	ICL7660		YY75S
IC2	74LS132		YF51F
Miscellaneous			
	P.C. board		GB26D
S1,2	DIL SPDT Single	(2 off)	XX28F
	Veropin 2145	(1 pkt)	FL24B

A complete kit of all parts is available
Order As LK17T. Price £7.50

Infra Red Dectector *Continued from page 21*

signals in the infra-red wavelength which are reflected and focussed by facets of the reflector. Each signal received is then amplified and filtered to prevent unwanted spurious signals from false triggering the relay. This is achieved by using a diode pump to charge a capacitor until a pre-determined threshold is reached. The mode can be changed by inserting a link between terminals C (3) and D (4) on TB 1 when single pulse operation is required. Relay RLA 1 once operated, closes a single pole contact with connections available on TB 2 terminals G (3) and H (4).

These contacts can only handle low power, so do not try to switch heavy loads or high voltages with them. The circuit is not self-Latching and does not require re-setting once tripped. Wire link LK 1, fitted to the terminal PCB can be removed or cut if LED 1 is not required to light during normal use. It does not have any effect on the rest of the circuitry.

An "anti-tamper" loop is run through the module and terminated on TB 2 E(1) and F(2). This would normally be used on four wire systems and is not compulsory.

Positioning of the module depends on the area to be protected, but recommended sighting would be 2 metres above floor level where coverage extends out oat 45 degree angles from both sides up to approximately 8 metres distance. The most sensitive area being in a direct line up to 10/12 metres. Movement within the zone in single pulse mode will trigger the unit, whereas double pulse mode will require a body to pass completely through the zone before detection.

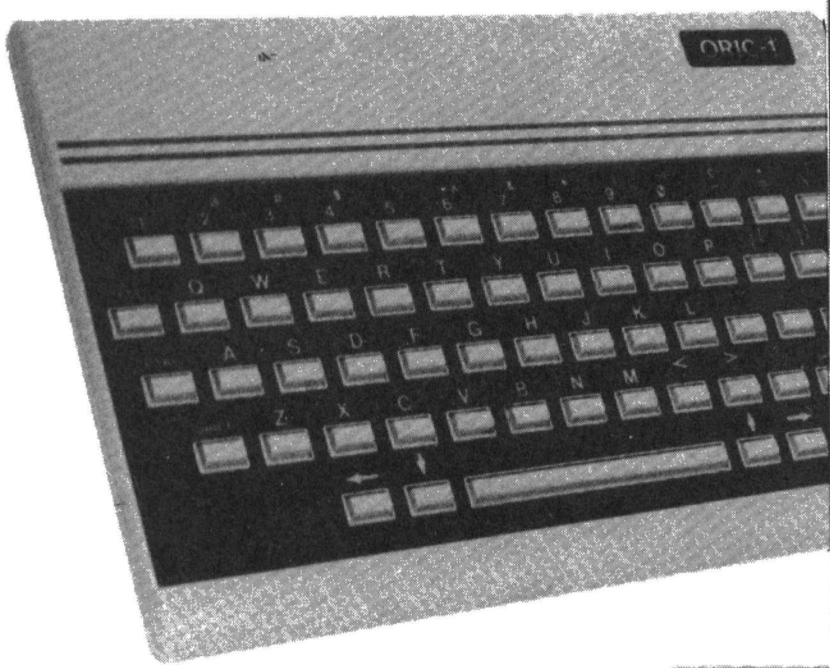
Connection to the Maplin Home Security System is easily achieved by inserting a 22k ohm resistor between relay terminals G and H on TB 2 and off to a break contact module in the usual way. A suitable power source is required, e.g. PSU and standby batteries for 12 volt operation at 20 mA (D.C.), and is not readily available from the master control unit.

This well designed and very smart unit is well suited for the protection of offices, shops or homes and is easily connected to most alarm systems requiring a 'make' switch action.

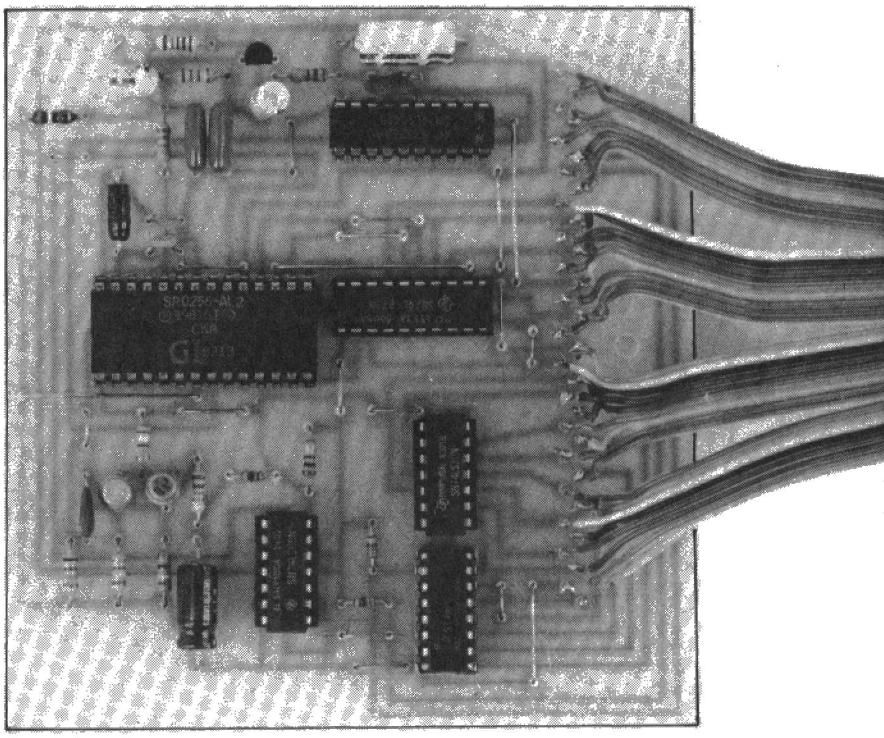
INFRA-RED MOVEMENT DETECTOR

Resistors		
R1,2	560R	(2 off)
R3	4k7	(1 off)
R4,5,16	47k	(3 off)
R6,8	68k	(2 off)
R7,19	1k8	(2 off)
R9	1M2	(1 off)
R10	330k	(1 off)
R11,12,13,15	100k	(4 off)
R14,20,21	33k	(3 off)
R17,18	4M7	(2 off)
RV1	100k Preset	(1 off)
Capacitors		
C1-C6	10uF 16V Tantalum	(6 off)
C7,8	0·022 uF ceramic	(2 off)
Semiconductors		
IRD1	RPY97	(1 off)
LED 1	Red LED	(1 off)
D1	1N4003	(1 off)
D2	1N4148	(1 off)
TR1-3	BC 182L	(3 off)
TR4	BCY71	(1 off)
REG 1	78L08	(1 off)
REG 2	78L05	(1 off)
IC1	LM324	(1 off)
Miscellaneous		
	PCB Main	(1 off)
	PCB Terminal	(1 off)
	Parabolic Reflector	(1 off)
RLA	5V, 1K Relay	(1 off)
SKT1	10 Way RA edge conn.	(1 off)
PL1	10 way Minicon plug	(1 off)
TB1,2	4 way PCB Terminal block	(2 off)
LK1	22SWG Tinned Copper Wire (see text)	
	Case — 4 Sections and Hardware	(1 off)
	Screws self tapping ¼" long.	(4 off)

This project is only available in kit form.
Order Code LK33L - Price £34.95



ORIC TALK BACK



by Robert Penfold

This speech synthesiser for the Oric 1 computer, like the previous Maplin "Talkback" projects, is based on the GI SP0256 speech chip. Rather than a vocabulary of complete words, this chip provides a set of short sounds known as "allophones" which are strung together to produce the required words. This system is slightly more difficult to use than one which uses whole words, and the speech quality is not quite as good, but it has the advantage of what is effectively an unlimited vocabulary. The required phrases can be produced using a short program which takes up very little memory space.

The Oric Talkback connects to the expansion and cassette ports at the rear of the machine. Power is obtained from the Oric and the speech is reproduced through the machine's internal loudspeaker.

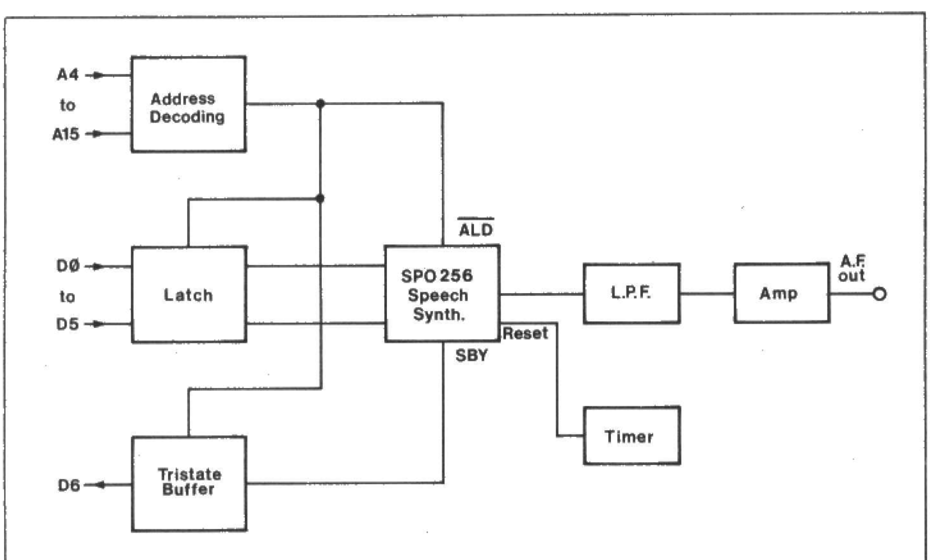


Figure 1. Simplified block diagram.

Block Diagram

Figure 1 shows a simplified block diagram for the unit. The twelve most significant address lines are decoded to place the circuit at addresses #BFF0 to #BFFF inclusive, and this is within the unused memory area (#BFE0 to #BFFF) of the Oric 1 48k, and is also free on the 16k version where the upper 32k of memory area is unused.

Data lines D0 to D5 are fed to the six address inputs of the SP0256 chip via a latch. The SP0256 has a set of 64 allophones (including pauses), and the required allophone is obtained by POKEing the appropriate figure to any address in the range #BFF0 to #BFFF. The address decoding circuit provides a negative pulse to the Address Load input of the SP0256, and the selected allophone is then produced. The circuitry within the speech chip is very

complex, and includes a digital filter followed by a pulse width modulator which supplies the audio output signal. The output from this modulator is in the form of a signal of fixed (ultrasonic) frequency, with the pulse length being varied from a short duration, to give a low average output voltage, to a comparatively long duration to give a high average output potential. It is the average output level that constitutes the audio output signal, and a lowpass filter is used to filter the ultrasonic content of the signal to leave just the required audio signal.

As the output from the filter is at a fairly low level an amplifier is used to boost the signal to an adequate amplitude to drive the audio input of the Oric. In fact the Oric does not have an audio input, and the "SOUND" input on the cassette interface socket is intended as an audio output for use with a hi-fi amplifier. However, it also seems to work perfectly well as an audio input, and a good quality audio output is obtained. The Oric's sound generator still functions properly when the speech synthesiser is in use.

Even a programme written in a relatively slow language, such as BASIC, is capable of supply allophone addresses to the circuit far faster than the allophones can be executed. The speech chip must therefore signal to the computer when it is ready to receive another address. In this case the STANDBY output of the SP0256 is used, and this goes to logic 1 when the chip is inactive. This output is connected to the D6 line of the computer via a tristate buffer which ensures that the STANDBY output only connects through to the data bus when an address between #BFF0 and #BFFF is PEEKed. A software loop is used to read D6 and to hold up the program until this bit goes high.

The Oric 1 48k computer has 64k of RAM with the 16k at the top of the address range overlaid by ROM. At switch-on there is an initialisation period of about two or three seconds, and towards the end of this the speech synthesiser would be activated. This is overcome by using a simple timer circuit to delay the reset pulse for the speech chip until the initialisation has been completed.

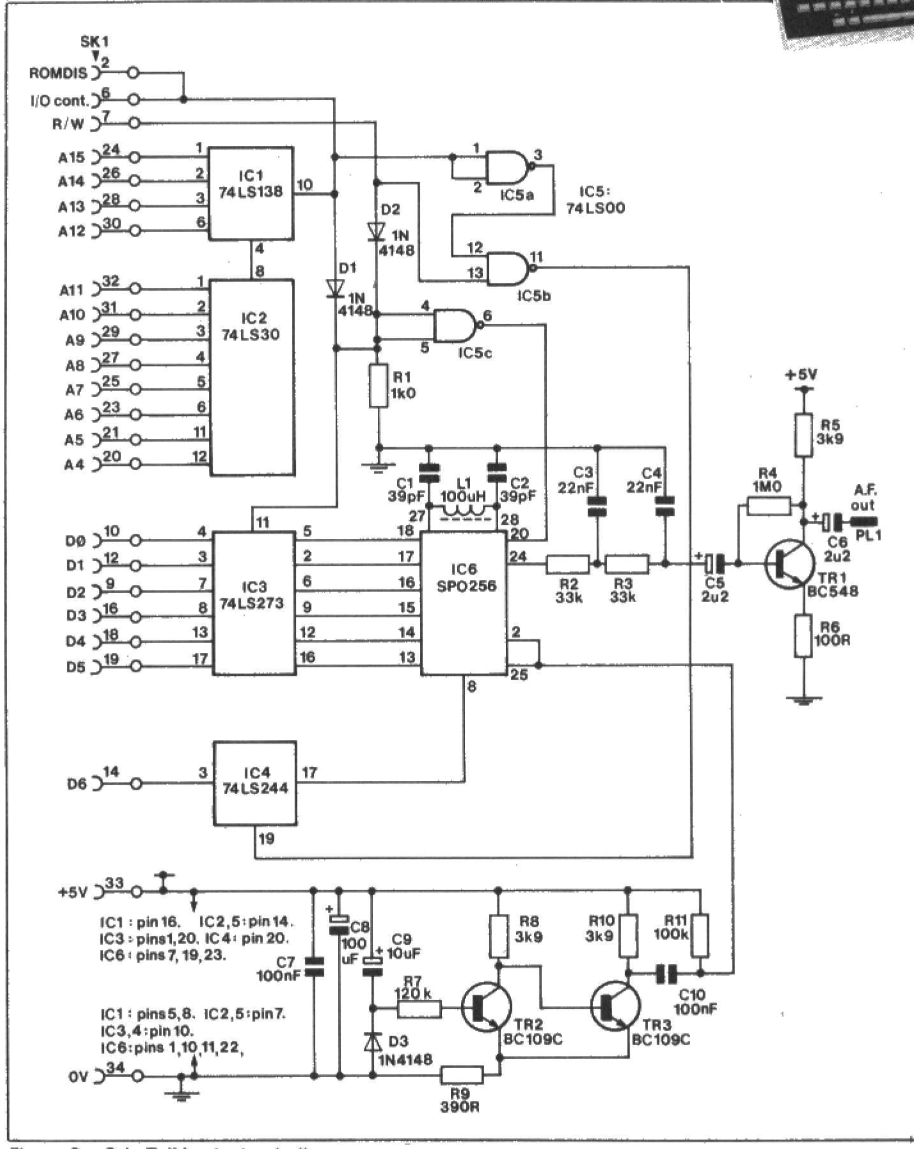


Figure 2. Oric Talkback circuit diagram.

The Circuit

Figure 2 shows the full circuit diagram of the Oric Talkback project.

IC1 and IC2 provide the address decoding. IC1 is a 3 to 8 line decoder, but by utilising the enable input the four most significant address lines are decoded. IC2 is an 8 input NAND gate and this is used to decode the middle eight address lines. Its output drives one of the negative enable inputs of IC1. A negative pulse is produced at pin 10 of IC1 when an address in the range #BFF0 to #BFFF is PEEKed or POKEd.

IC3 is the latch, and only six of the D type flop/flops in this device are used here. D1, D2, and R1 gate the output of IC1 with the Read/Write output of the computer so that the latch is only operated during a write operation to the unit. IC4 is the tristate buffer, and only one section of this octal device is used in this circuit. IC5a/b gate the output of IC1 with the Read/Write line so that IC4 is only enabled during read operations to the circuit.

IC6 is the SP0256 speech chip, and this requires a nominal 3.12MHz clock signal. This device has a built-in clock oscillator which can be used with a crystal having a resonant frequency of around 3.12MHz, but in this circuit the inexpensive alternative of a simple inductor (L1) is used. However, a crystal can be used in place of L1 if desired, and no other modifications to the circuit would be needed.

The lowpass filtering at the audio output of IC6 is provided by R2, C3, R3, and C4. TR1 is used as a common emitter amplifier which boosts the audio output of the circuit to an adequate level. The volume obtained should be perfectly satisfactory, but if desired a higher output can be produced by making R6 a little lower in value, or a higher value can be used to reduce the output level.

The negative pulse which is used to operate the latch is inverted by IC5c and fed to the Address Load terminal (pin 20) of IC6. The speech chip is activated at the end of the address pulse when the output of IC5c goes negative. While it might seem more logical to drive the Address Load input without the inverter stage, this method does not work properly in practice. A minor drawback with this method of activating the chip is that it does not switch off when an allophone has been completed. However, this is overcome in the software by finishing each phrase with a pause which effectively switches off the chip.

TR2 and TR3 are used as a conventional Scmitt Trigger circuit, and in conjunction with timing components C9 and R7 this provides the delayed reset pulse for IC6.

As the Oric 1 48k computer has 64k RAM chips all the addresses (including the spare ones between #BFE0 and #BFFF) are occupied by RAM. When reading from an external device it is therefore necessary to disconnect from the data bus the RAM plus any other internal devices which might place an output onto the data bus. This is achieved by connecting the I/O control and ROMDIS lines to the output of IC1 so that they are taken low during read operations of the circuit.

Construction

All the components are fitted on the printed circuit board, as detailed in Figure 3. Start by fitting the link wires, diodes and resistors, and then fit the capacitors, inductor, transistors and finally the integrated circuits. It is not essential to mount IC1 to IC5 in sockets, but as IC6 is a rather expensive MOS device a (28 pin DIL) socket should certainly be used for this component. Other normal MOS handling precautions should also be observed when dealing with IC6. Be careful to fit the integrated circuits with the correct orientation.

PL1 is a 7 way DIN connector, and pin 4 or 5 of this is connected to the printed circuit board via an insulated lead about half a metre to a metre in length. It is not necessary for this lead to be a screened type. If preferred the output of the unit can be coupled to headphones or an amplifier instead of the cassette interface socket of the Oric. SK1 is a 34 way IDC header socket and this connects to the board by way of a 34 way ribbon cable, again about half a metre to a metre in length. Make quite sure that it is connected the right way round. If you are uncertain about the correct method of connection for either SK1 or PL1 refer to Appendix F on page 151 of the Oric manual.

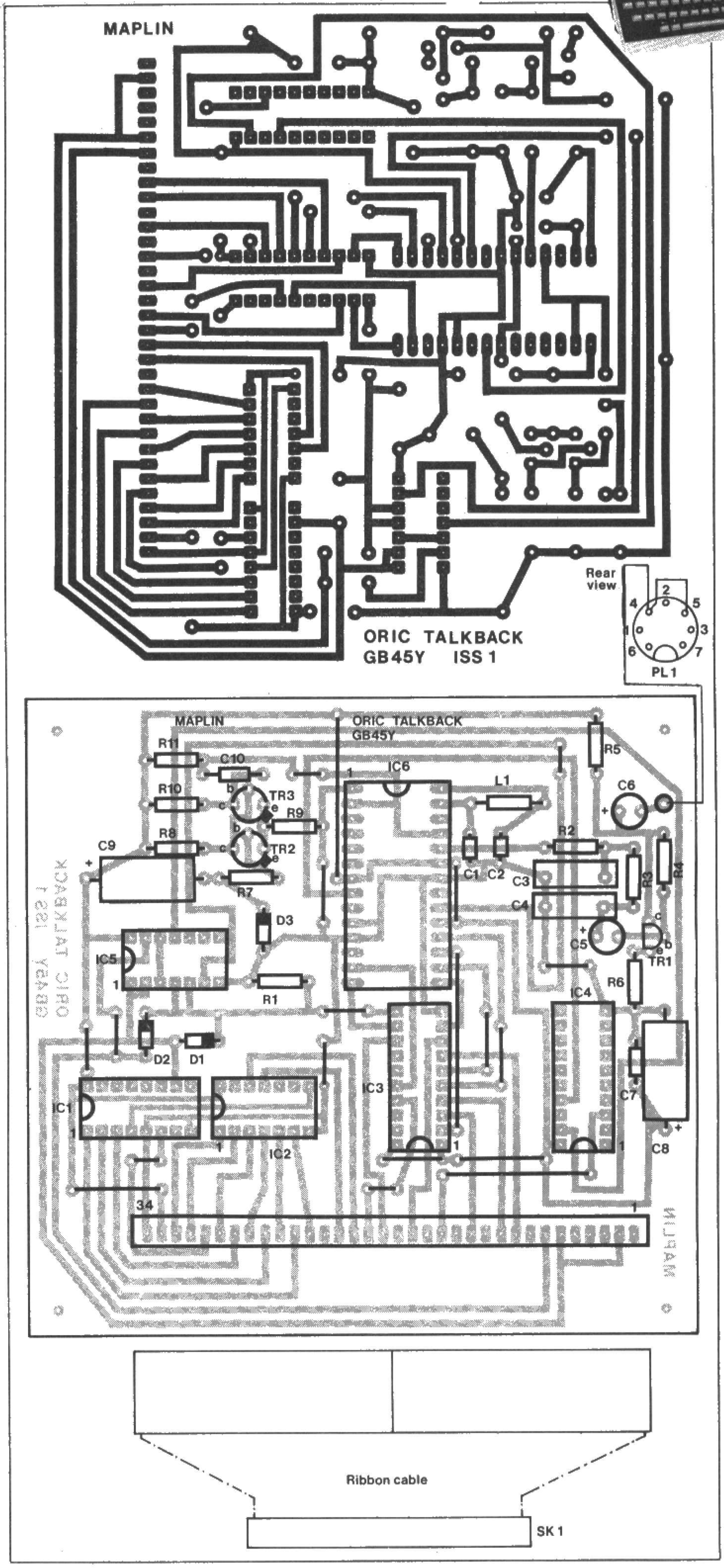
Testing

Connect the unit to the expansion port before applying power to the computer. Connecting or disconnecting the unit while the computer is operating will almost certainly cause it to "hang up", and could conceivably result in damage to one or other of the units. If the synthesiser is operating properly a quiet "click" should be heard from the loudspeaker a few seconds after switch-on when the SP0256 is reset. Using the command POKE #BFFF,55 should give a noise sound from speaker, and POKE #BFFF,2 should switch off the noise. Assuming all is well, one of the test programs can then be tried.

Software

More information about speech synthesis and the use of allophones can be found in issue 6 of this magazine. Please note a copy of the article on Allophones is supplied with the kits.

As the number of allophones will vary from one phrase to another it is awkward to use FOR..NEXT loops since the number of steps must be matched to the number of allophones. A REPEAT...UNTIL loop as in listing 1 is a better solution. A value of 130 is used at the end of the DATA to terminate the loop, and the lower six bits are read by the speech synthesiser as 2 so that the pause to switch off the synthesiser is obtained. 65 could be used as the terminator, but a three digit number stands out better and this is helpful when debugging or altering a program with more than one phrase. Line 40



Pcb Layout for The Oric Talkback.

```
5 REM listing 2
10 DIM SPEECH(20,3)
20 REPEAT
30 PHRASE=0
40 REPEAT
50 READ ALPHN
60 SPEECH(PHRASE,N)=ALPHN
70 PHRASE=PHRASE+1
80 UNTIL ALPHN>63
90 N=N+1
100 UNTIL N>3
110 REPEAT
120 GET PHRASE
130 S=0
140 REPEAT
150 POKE #BFFF,SPEECH(S,PHRASE)
160 REPEAT:UNTIL(PEEK(#BFFF)AND64)
170 S=S+1
180 UNTIL SPEECH(S-1,PHRASE)>128
190 UNTIL FALSE
200 DATA 16,26,9,45,12,11,130,19,45,7,41,13,39,24,11,12,41,130
210 DATA 55,15,9,45,6,55,130,14,31,45,2,53,1,8,20,130
```

```
5 REM listing 1
10 REPEAT
20 READ A
30 POKE #BFFF,A
40 REPEAT:UNTIL (PEEK(#BFFF)AND64)
50 UNTIL A>63
60 DATA 46,7,11,2,59,2,49,22,2,61,53,19,56,2,13,22,2
70 DATA 45,7,17,2,16,19,2,32,17,2,24,35,2
80 DATA 16,6,2,63,24,41,55,130
```

Listings 1 and 2

reads input line D6 and provides the delay until the SP0256 signals that it is ready to receive another allophone. Although it may appear that "=64" has been omitted from this line, due to the way in which Oric BASIC works this is unnecessary and would simply slow things down. The program includes a sample phrase in lines 60 to 80.

A problem with Oric BASIC is that it is not possible to RESTORE to a particular line number — only to the start of a DATA list. This makes it difficult to hold phrases in a long program where data statements may also be used for other purposes, such as redefining characters and for SOUND statements. The most elegant way around this is to READ the DATA into arrays at the start of the program, as in listing 2. The first part (10 — 100) READs the data into the array SPEECH. This can hold four phrases of up to 21 allophones (remember that element 0 is valued in Oric BASIC).

The second part produces the speech, and line 120 lets you choose a phrase by pressing a number key (0 to 3). Lines 110 to 190 could be made subroutines in a large program, with RETURN added at the end. Line 120 should then be omitted, and PHRASE passed as a variable when calling the subroutine (e.g. PHRASE = 3 : GOSUB 100). With the example phrases pressing keys 0 to 3 in that order produces a message from MAPLIN.

L1 100uH CHOKE (WH41U)
FROM VOL. 3 NO10 P.86

ORIC TALKBACK

Resistors — All 0.4W 1% metal film			
R1	1k0		(MIKO)
R2,3	33k	(2 off)	(M33K)
R4	1M0		(M1M0)
R5,8,10	3k9	(3 off)	(M3K9)
R6	100R		(M100R)
R7	120k		(M120K)
R9	390R		(M390R)
R11	100k		(M100K)
Capacitors			
C1,2	39pF ceramic	(2 off)	(WX51F)
C3,4	22nF polyester	(2 off)	(BX72P)
C5,6	2u2F63V PC electrolytic	(2 off)	(FF02C)
C7,10	100nF Disc	(2 off)	(BX03D)
C8	100uF10V axial electrolytic		(FB48C)
C9	10uF25V axial electrolytic		(FB22Y)
Semi conductors			
IC1	74LS138		(YF53H)
IC2	74LS30		(YF20W)
IC3	74LS273		(YH00A)
IC4	74LS244		(QQ56L)
IC5	74LS00		(YF00A)
IC6	SP0256		(QY50E)
D1,2,3	1N4148	(3 off)	(QL80B)
TR1	BC548		(QB73Q)
TR2,3	BC109C	(2 off)	(QB33L)
Miscellaneous			
SK1	34 way IDC socket & cable		(BK96E)
PL1	7 way DIN connector		(HH30H)
	Printed circuit board		(GB45Y)
	14 pin DIL socket	(2 off)	(BL18U)
	16 pin DIL socket		(BL19V)
	20 pin DIL socket	(2 off)	(HQ77J)
	28 pin DIL socket		(BL21X)
	Cable hook up	1 pkt	(BL00A)
Optional			
	Minicon latch plug, 17 way	(2 off)	(BH61R)
	Minicon latch housing, 17 way	(2 off)	(RK69A)
	Minicon terminal	(34 off)	(YW25C)

A complete kit of parts is available.
Order As LK28F Price £26.18

Rewiring Your House

Part 2
by Geoffrey Burdett

Electricity in the bathroom

Electricity is used extensively in the modern bathroom — for lighting, heating, hot water, for shaving and for condensation removal. Special precautions are required by the IEE Wiring Regulations in a room "containing a fixed bath or shower".

Provision must not be made for the use of portable mains voltage appliances except for a shaver which must be used from an authorised shaver socket.

Appliances must be fixed, which is defined as requiring tools to move them. Switches must be fixed out of reach of a person using the bath, except the insulated cord of a cord operated ceiling switch.

Lighting switches are normally of the cord operated type as also is the shower heater isolating switch.

Lighting fittings should be either of the flexless close ceiling type with its lamp protected by a deep lamphoder skirt, termed at HO (Home office) skirt to prevent the lamps' metal cap being touched when the lamp is in contact with the lampholder pins. Or the lighting fitting should be of the totally enclosed type.

Shaving mirror lighting

Fix the light so that the face, not the mirror is illuminated. This can be a striplight but it must be made to BS 4533 which prevents the lampholder contacts being touched when changing a lamp. It is operated by a cord switch. The striplight can conveniently contain a shaver socket but it must conform to BS 3052 and contain an isolating transformer.

Shaver supply units

A shaver supply unit permitted in a bathroom and made to BS 3052 contains an isolating transformer which provides a non-earthed 240V supply of electricity to the shaver socket. It also contains a thermal, self setting cut out which prevents other than shavers being used from the unit.

Some shaver units are dual voltage 240V/115V the change-over being made either at a switch or by selecting two socket pins for the different razor voltage. A shaver supply unit for a bathroom may be connected either to the ring circuit using 2.5mm^2 twin & earth flat pvc sheathed cable, or to a convenient point on the lighting circuit using 1.0mm^2 twin & earth pvc flat sheathed cable. Shaver sockets designed for rooms other than the bathroom usually have to be connected to a lighting circuit.

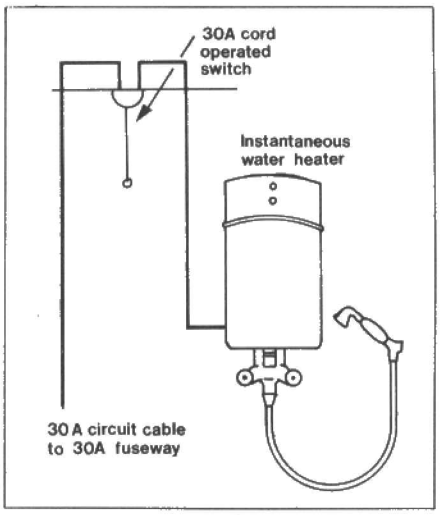


Figure 1. Fitting an instantaneous water heater of a shower unit.

Bathroom heaters

Four types of electric heaters are suitable for a bathroom: (i) radiant wall heater; (ii) oil filled radiator with or without towel rail; (iii) heated towel rail; and (iv) heat/light unit.

Radiant wall heater

This heater has one or more glass silicon enclosed spiral elements situated in front of a highly polished chromium plate reflector.

It must be situated high up on the wall out of reach of anyone using the bath. Although having an integral cord operated switch the heater requires a double-pole isolating switch to comply with regulations. The switch can conveniently be that of a switched fused connection unit supplied from a spur on the ring circuit. The unit should have a flex outlet for the flexible cord of the heater and preferably a pilot light.

Oil filled radiator

A thermostatically controlled oil filled radiator is especially suitable for a bathroom and can incorporate a towel rail. It is fixed to the wall or floor out of reach of a person using the bath. It can be supplied from a fused spur on the ring circuit the cable terminating at a cord outlet unit fixed near the heater and connected to it by 3-core flexible cord.

Heated towel rail

A popular towel rail is a plastic tube bent int the form of an 'S'. It is used where the bathroom is heated by another form of heater e.g. radiant reflector fire or heat/light unit. As the heater has such a low wattage it is best run off the lighting circuit and controlled by a 5A cord operated switch.

Heat/light unit

A heat/light unit is usually of circular construction containing a 750 watt glass silicon enclosed element and a 100 watt electric light bulb. The heater is independently switched by a cord operated switch. It can be placed in the usual position of the bathroom ceiling light but because of its comparatively high loading must not be connected to the lighting circuit wiring. Instead it should be supplied from its own 5A circuit or from a fused spur on the ring circuit. In the absence of a spare circuit fuseway, the spur is the better alternative. When replacing a conventional light, remove the old light and draw the cables back into the void and terminate them in a junction box. Remove the light switch and do likewise with the cables. Run the spur cable from a fused connection unit situated next to the socket outlet, where the connection to the ring circuit cable is made, to the new double — pole 15A cord operated switch. From the switch run another length of cable (1.5mm^2) to the heat/light fitting. There is also a wall type heat/light unit the heater being of the fan-assisted type.

Extraction fan

An extraction fan will keep the bathroom clear of condensation and introduce fresh air into the bathroom. This can be the window type which is fixed into a hole cut in a pane of glass. As it is difficult for the installer to cut a hole it is better to take the maker's template to a glazier to fit the required hole in a new pane of glass which is then fitted in place of the existing pane. Careful removal of the old pane will save the purchase of a new one. The fan can be supplied from the lighting circuit using 1.0mm^2 twin & earth flat pvc sheathed cable connected to a convenient loop-in ceiling rose or junction box. Run the cable to a fused clock connector fixed on the wall next to the fan. Connect the fan to the clock connector using 3-core circular pvc sheathed flexible cord. The fan is operated by an integral cord switch.

Shower unit

A shower unit is an instantaneous water heater having a loading of 5kW or 7kW (see Figure 1). It does therefore require a 30A circuit using 6.mm^2 twin and earth flat pvc sheathed cable from a circuit fuse or mcb of 30A current rating. Where there is no spare fuseway in the consumer unit it is necessary to install a new 30A switchfuse unit containing either a circuit fuse or an mcb. The new switchfuse unit (if required) is connected to the mains by the electricity board using 16mm^2 single-core pvc sheathed cables, one black, the other red, about one metre long fitted to the unit by the installer. The unit is connected to the board's earthing terminal using 6mm^2 green/yellow earthing cable. The circuit cable is run to a 30A double-pole operated ceiling switch, with pilot light. From the switch a length of

the same cable is run down the bathroom wall to the shower unit.

Wash basin water heater

The water heater fitted at a wash basin has a loading of 3kW and can be supplied from the ring circuit (see Figure 2). The outlet must be a fused connection unit, not a socket outlet. The unit has a cord outlet for the flexible cord of the water heater and should preferably have a neon indicator. The connection unit should be the switched type the switch serving as the necessary isolating switch, but it should be fixed in a position where it cannot be touched by a person using the bath.

Electricity in the kitchen

Many of the electrical appliances used in the kitchen are of high loading and a number of those in the 3000W range are used at the same time. This means that the circuit requirements must take into account that the current demand will be exceptional compared with other parts of the house.

The electrical facilities in the kitchen can be conveniently divided into four main sections:

(i) lighting.
(ii) 13A socket outlets for portable appliances and fused connection units, for fixed or stationary appliances having individual loadings of up to 3000 watts.
(iii) Free-standing or built-in cooker having a total loading in excess of 3000 watts.
(iv) Instantaneous water heater having a loading of up to 6kW.

Lighting in the kitchen

The lighting in the kitchen normally will consist of a good general light, switched at the access door, and supplementary lighting at the sink, the cooker and elsewhere if necessary. The general light can be either a 100/150 watt tungsten filament bulb or the equivalent flourescent tube, e.g. 40 watts. The light over the sink is usually a flourescent tube for best results, locally switched, with the general centre light a tungsten filament fitting (which is better as it is frequently switched on and off by people entering and leaving the kitchen after short intervals). The life of a flourescent tube is in fact reduced by continually switching it on and off. Even though the cooker has a hoblight, a separate light is sometimes needed at the hob. This can be a wall mounted spotlight.

Where the kitchen is used as a breakfast room, especially if fitted with a bar, down lighters are the preferred type of lighting fittings, these being recessed into the ceiling.

An alternative lighting scheme is the illuminated ceiling, but unless the ceiling is high, as in some older houses, this can have a depressing effect. The lighting consists of fluorescent tubes fixed to the original ceiling and enclosed by translucent panels fitted on to a suspended grid. Downlights and "eyeball" fittings are also used in conjunction with an illuminated ceiling.

Socket outlet circuits

The 13A socket outlets should be distributed throughout the kitchen and for the most part should be double sockets. The socket outlets should be fixed at about 300mm above a work top and about 1 metre above floor level, where there is no worktop (see Figure 3). For fixed or stationary appliances such a the refrigerator, freezer, built-in washing machine, or central heating pump and electrics, the switched fused

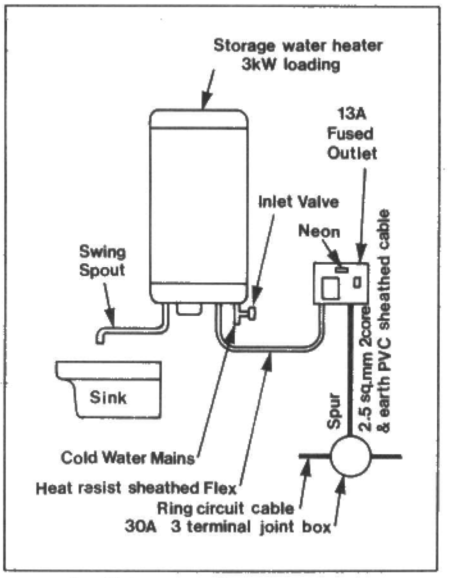


Figure 2. Fitting a small storage water heater over a wash basin.

connection unit is usually the better alternative, as it prevents the outlet being used for a portable appliance, although only temporarily. The ground floor ring circuit usually passes through the kitchen, but because of the large number of appliances in use at any one time it is best to install a 30A radial power circuit in addition, for this may supply an unlimited number of 13A outlets within an area of $50m^2$.

The cooker circuit

An electric cooker having a loading in excess of 3kW, but not exceeding 12kW, can be supplied from a 30A circuit. The circuit is normally wired in $6mm^2$ twin & earth flat pvc sheathed cable. Although the maximum possible current demand of a 12kW cooker is 50 amps, a 30 amp circuit is permitted because account is taken of the fact that rarely are all boiling rings, grill and oven switched on at the same time, and when they are, individual thermostatic devices reduce the current demand.

The regulations give a formula for working out the assessed current demand. This is 100% of the first 10 amps plus 30% of the remaining current, plus 5A for a kettle socket, where this is mounted on the cooker control unit. For a 12kW (50A) cooker, plus kettle socket, this works out as follows: 10 amps, plus 30% of the remaining 40 amps, which is 12 amps, plus 5amps for the kettle socket, making a total assessed current of 27 amps. Where the loading of the cooker is in excess of 12kW, a 45A circuit wired in $10mm^2$ twin & earth flat pvc sheathed cable is required. The cooker circuit originates at a 30A or a 45A circuit fuse or mcb, but where there is no spare fuseway in the consumer unit, it is necessary to install a switchfuse unit of the appropriate current rating, as

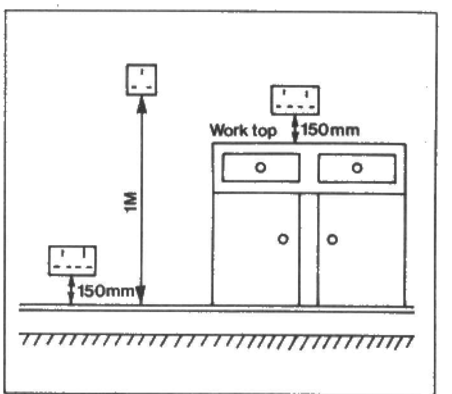


Figure 3. Fitting socket outlets in a kitchen.

described for a shower circuit. The circuit cable terminates in a cooker control unit fixed on the wall next to the cooker. This unit has a current rating of 30/45 amps and normally contains a 13A switched socket outlet for an electric kettle. The control unit for a free standing cooker should be fixed to one side of the cooker at a height of about 1.5m and within 2m of the cooker. Where it is not practicable to fit the control unit other than above the cooker, the socket outlet should be omitted, otherwise the kettle flex might drape over a switched-on boiling ring. From the cooker control unit, runs another length of the same cable, down to a cable outlet terminal box fixed to the wall about 500mm above floor level (see Figure 4). Connect another length of the same cable to the box, its other end to the cooker terminals with sufficient slack to provide a trailing cable when moving the cooker.

The two sections of a split level cooker are supplied from the one circuit and provided each is within 2m of the control unit, the one unit may serve both. The circuit cable is run into the control unit, usually fixed between

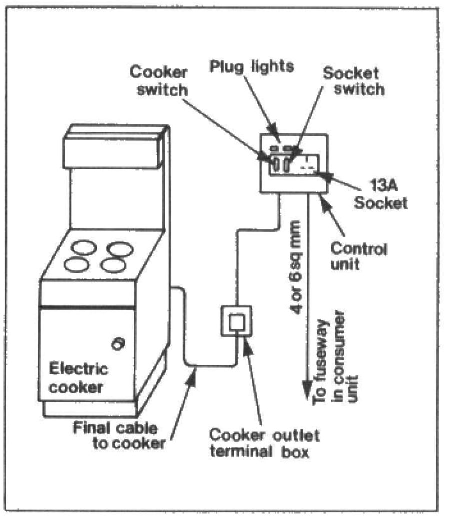


Figure 4. Fitting a cooker control unit.

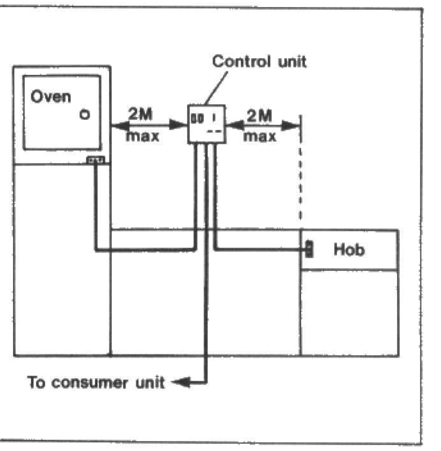


Figure 5. Controlling a separate oven and hob.

the two sections. From the control unit two additional lengths of the same size and type of cable are run, one to the terminals of the hob section, the other to the terminals of the oven section (see Figure 5).

Sink water heater

A 3kw sink storage water heater can be supplied from a switched fused connection unit connected to the ring or the radial circuit. The connection unit should have a cord outlet for the flex of the water heater. An instantaneous water heater for the kitchen sink requires a loading of 5 or 6kW, and is supplied from a 30A circuit. For the circuit

4.0mm² twin & earth pvc sheathed cable may be used, provided the circuit fuse is of the cartridge type or an mcb is used. A wall mounted 30A double pole switch is fixed near the water heater and connected to the water heater using 4.mm² twin and earth flat pvc sheathed cable, or 3-core flexible cord.

A waste disposer and the central heating are supplied from spurs and connected to switched fused connection units.

Space heating

Some form of electric heating is usually needed in the kitchen especially for use when the central heating boiler is not being used. Owing to the shortage of space in a kitchen a high-mounted radiant reflector is a good choice and is supplied from a spur, as in a bathroom.

Extractor fan

A kitchen needs frequent changes of air, this being provided by an extractor fan. It can be fitted into the window, provided it does not affect the air flow to the boiler. Reversible types are controlled by a wall mounted reversing switch. An alternative is a wall mounting extractor fan, but this needs a duct to pass through the exterior wall.

The fan can be supplied from a ring circuit spur via a switched fused connection unit, with cord outlet and with or without neon indicator.

Cooker hood

Although an extractor fan will expel cooking fumes, the fumes may have to pass through much of the kitchen and deposit grease on the walls, ceiling and equipment. Instead it is usually preferable to install a cooker hood. One type contains grease and fume filters to recycle the air and prevent serious heat loss. Another type is the fan assisted version, which is ducted in through the exterior wall. Some versions are a combination of both. The hood can be supplied from a 13A switched socket outlet fixed near the cooker, though the kettle socket on the control unit can be used for this purpose.

Electricity in the garden

Electricity is used out of doors for lawnmowers, trimmers, hedgetrimmers and for other electrical tools and appliances including electric drills plugged into socket outlets.

It is also used for garden lighting, pathway and building outside lighting, and for the fountain in the pool.

Positions for socket outlets

One of the best positions for an outdoor socket outlet is on the outside wall of the house where there is usually a concrete terrace, path or patio.

In this position the socket outlet can be fed from the house ring circuit in the form of a spur.

To do this drill or knock a hole in the outside wall above the damp course, at a point where it will be directly at the back of the socket, to pass through the base of the socket mounting box, this avoids running a cable along the exterior wall.

In the house the spur cable is connected t the terminals of a conveniently situated socket outlet where the new cable is readily run into the socket box. From there the spur cable, consisting of 2.5mm² twin & earth flat pvc sheahed cable, is run in the void under

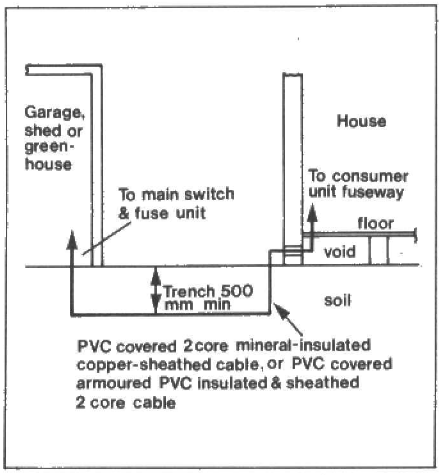


Figure 6. Burying an armoured cable.

the floor, brought up behind the skirting board, and through the hole cut into the outside wall (see Figure 6).

Although a metal-clad socket outlet is more robust than the moulded plastic type, there is much to be said for using the standard plastic socket outlet because this can readily be fitted with a protected cover. The cover is hinged at the top to allow it to be used with the fused plug inserted into the socket.

A socket outlet of this type can be fitted to the exterior wall of a garage and also to the garden shed, but in this case it is usually better to fix the socket inside the shed and run the flexible cord of the mower or hedgetrimmer into the shed.

Socket outlets in other parts of the garden should be mounted on substantial posts, at a height of about 300mm above general ground level. The socket outlets should be of the weatherproof type or otherwise be protected by enclosure. Where a garden is subject to flooding during parts of the year, either avoid these areas or mount the sockets higher. The cable feeding these sockets should be buried in the ground, the minimum regulation depth being 500mm where there is no deep digging, but deeper if necessary, where the cable is likely to be disturbed.

Underground cable

There are two types of cable which may be laid directly into the ground. One is pvc covered, mineral-insulated, copper-sheathed (MICS) cable, as made by BICC Pyrotenax Ltd. The other is pvc covered, wire-armoured, pvc/pvc insulated and sheathed cable.

The 2-core version of MICS cable is used as the copper sheath provides an effective earthing conductor.

The 2-core version is also used in wire armoured cable with the wire armour being used as the earth conductor, but because electricity board engineers regard the armour as having poor conductivity, the tendency is to install 3-core, the third core being used as the earth conductor. The MICS cable is the preferred cable because it has very small cross-sectional area, whereas wire armoured cable is of large cross-sectional area and difficult to insert into socket boxes.

The snag with MICS cable is that the mineral insulation is moisture absorbing, which necessitates a seal being fitted to each end.

A screwed flange is also fitted at the end, if it is to be screwed into an accessory box, and provides good earth continuity. Screwed glands are also fitted on the ends of wire armoured cable, although seals are omitted.

MICS seals and kits of materials and special tools, together with instructions are available from the cable makers; BICC Pyrotenax Ltd. or from the retail supplier.

Ordinary twin and earth flat pvc sheathed cable may be buried in the ground as an alternative to a special cable, but it must be enclosed throughout its length in rigid plastic conduit. This can be a cumbersome job especially at the socket outlets, and is hardly less expensive.

Fountain in pool

The pump of the fountain in the home garden is usually of low voltage and is supplied from a mains transformer. The transformer should be protected from the weather, as also should the mains socket outlet into which it is plugged. The wiring is the same as for any other outdoor socket outlet.

Personal protection from electric shock

It is now a requirement that a socket outlet, supplying a power tool or appliance used out of doors, shall have a protective device fitted to prevent the user from receiving a severe or fatal electric shock. Combined socket outlets and current operated elcb's are now available and can be fitted where an indoor socket supplies the appliance. These elcb's are now termed Residual Current Devices (RCDs). For other socket outlets in the garden the circuit itself needs an RCD, this being fixed in the house. An alternative is an RCD in the form of a 13A fused plug for fitting to the end of the flexible cord in place of the conventional fused plug. See Earth Leakage Circuit Breakers.

Lighting outside the house

Principal lighting outside the house is usually the fixed lighting on the house structure. This includes the front porch light, the light outside the back door, usually either being a bulkhead or a bracket fitting. The lights are supplied from the house lighting circuit, usually with the switches on the inside of the house, but the backdoor light can be readily switched from the outside as well, using the MK Seal 2-way switch. Other lights can be outside the garage and shed, where fitted with electricity. Gate lighting requires a cable laid underground, as does pathway and driveway lighting. Other fixed light are mains voltage spot and floodlights, fixed to the eaves or house wall. Versions for planting in the garden, by means of a ground spike, are also available.

Low voltage floodlights operated from a mains transformer are also made in the form of kits of two or four floodlights, ground spikes, wall brackets, colour lenses, a long cable and the mains transformer.

For festive lighting use mains voltage festoons, designed for outdoor installation. These are in the form of lanterns and are supplied in kit form the lanterns being in various colours.

Earth Leakage Circuit Breakers

An earth leakage circuit breaker is a form of double-pole switch, which automatically switches itself off when electric current leaks to earth, and in so doing passes through the ELCB. There are two principal types of ELCB. One is the current operated type, where the fault current causes an out of

Continued on page 41.

Personal Stereo D·N·L

★ SMALL AND PORTABLE
★ IMPROVES SOUND QUALITY
★ EASY TO BUILD

by Robert Penfold

Most personal stereo cassette players are capable of a creditable level of performance, but a weakness of all but a few of the more recent and expensive machines is a lack of any proper form of noise reduction circuit. Most units simply have a high/low tone switch which gives a certain amount of treble cut in the "low" position and helps to keep down the amount of tape noise.

This add-on noise reduction unit simply plugs between the personal stereo unit and the headphones. It is a dynamic noise limiter, which is merely a form of lowpass filter. However, the cut-off frequency of the filter is not fixed, and it varies in sympathy with the dynamic level of the input signal. With little or no input to the unit the cuf off frequency would be quite low at about 4 or 5kHz, but at higher input levels the cutoff frequency would be forced upwards, reaching perhaps 15 or 20kHz, with the input at its maximum level.

This gives a large amount of noise reduction at low volume levels, but at high volume levels the amount of noise reduction is negligible. In practice the ineffectiveness of the system at high dynamic levels does not matter since the noise will be masked by the main signal and will not be noticeable anyway. In fact the lack of filtering is an advantage since it avoids an unnecessary reduction in the high frequency performance of the system. The weakness of a single-ended noise reduction system of this type is that it does reduce the treble response at low dynamic levels, and to a lesser extent at medium signal levels, but it is nevertheless a great improvement in comparison to a simple top-cut filter.

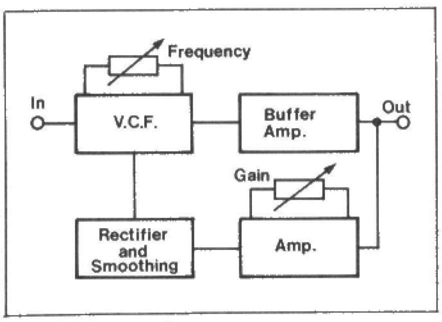
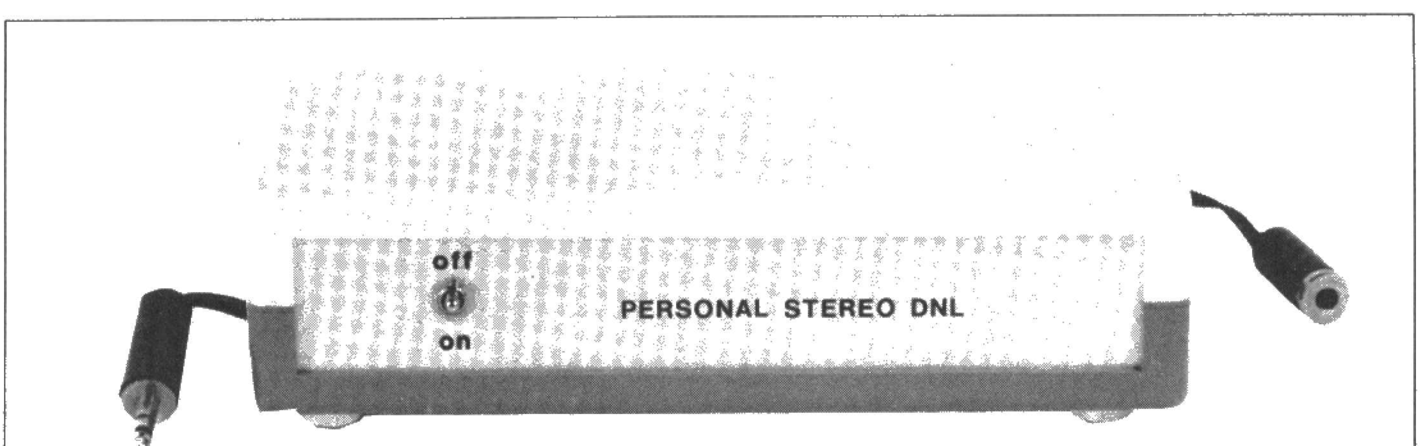


Figure 1. Block diagram.

Circuit Operation

The arrangement used in the DNL unit is outlined in the block diagram of figure 1. This is for one channel only, but with units of this type the two stereo channels are processed by separate but identical circuits.

The lowpass filter is a voltage controlled type, and a preset control enables the cutoff frequency (under quiescent conditions) to be set at a suitable figure. The filter cannot directly drive the headphones which typically require a maximum input voltage of about 1 volt RMS into an impedance of only about 35 ohms. A



buffer amplifier which provides a suitably low output impedance and drive current capability is therefore used at the output of the filter.

Some of the output of the unit is coupled to an amplifier. The amplified signal is rectified and smoothed to produce a control voltage for the VCF. With low level input signals the control voltage is too small to have any significant effect on the VCF, but at higher input levels there is a roughly proportional increase in the control voltage, and the cutoff frequency of the filter is moved higher, giving the desired effect. The gain of the amplifier has been made variable so that the unit can be adjusted to only fully remove the treble cut when the input signal reaches its maximum level.

Figure 2 shows the circuit diagram for one channel of the unit. Most of the components are duplicated in the other channel. As is standard practice, these components have the same identification numbers in the components list and printed circuit overlay, but with one hundred added (e.g. what is R8 in one channel is R108 in the other). Note that IC1 is a dual device which has one section used in each channel of the unit (the pin numbers in brackets are those for the second channel). The battery, on/off switch S1, and supply decoupling capacitor C8 are common to both channels.

IC1 is a transconductance operational amplifier which is used as the basis of the VCF. This is a straightforward 6dB per octave circuit with the values of bias and feedback resistors R3 to R6 chosen to give approximately unity voltage gain. However, the circuit will have less than unity gain if the bias current fed to the amplifier bias input (pin 1) is inadequate in relation to the load impedance from the output of the amplifier to the earth rail. This impedance is largely formed by C3, and as the impedance of a capacitor decreases as signal frequency is increased, at some point the impedance of C3 must become so low that the gain of the circuit is rolled-off. RV1 and R7 supply a quiescent bias current to the filter, which, strictly speaking, is a current rather than a voltage controlled type. By means of RV1 the cutoff frequency of the filter can be set at the desired figure. Of course, by applying an increased bias current the cutoff frequency can be raised, and with a high enough current it will be taken beyond the upper limit of the audio spectrum so that the treble cut is effectively eliminated.

The signal across C3 is coupled to the output amplifier via an internal buffer amplifier of IC1. The output amplifier consists of an operational amplifier (IC2) plus a discrete complimentary emitter follower output stage to boost the output current capability of the circuit to an acceptable level of high frequency distortion. D1 and R9 were therefore added to give a small quiescent bias voltage across the bases of the output transistors, and this leaves no significant crossover distortion.

TR3 is used as a simple common emitter amplifier which amplifies the output signal prior to rectification and smoothing by D2, D3 and C7. RV2 gives a controlled amount of negative feedback to the amplifier and enables the voltage gain to be varied between about 14 and 40dB. The bias voltage developed across C7 is fed to the amplifier bias input of IC1 via R12, and the current that flows through R12 in the presence of a strong bias voltage gives the required modification of the filter's cutoff frequency. The value of C7 and other components in the control voltage circuit produce rapid attack and decay times, and this is essential if the unit is to operate efficiently, and the changes in frequency response are not to be apparent to the user. As the circuit only processes high frequency signals it is possible to have attack and decay times of only a few milliseconds without introducing significant distortion.

Coupling capacitor C5 has been given quite a low value so that bass and lower middle frequencies are not efficiently coupled to TR3. This avoids having strong low frequency signals, which would not mask the noise, from operating the VCF and lifting the treble cut.

The current consumption of the circuit is only about 9 milliamps under quiescent conditions, and does not increase dramatically at high volume levels. A PP3 size battery is therefore adequate as the power source, although a higher capacity battery such as six HP7 (AA) size cells would probably be a better choice if the unit is likely to receive a great deal of use.

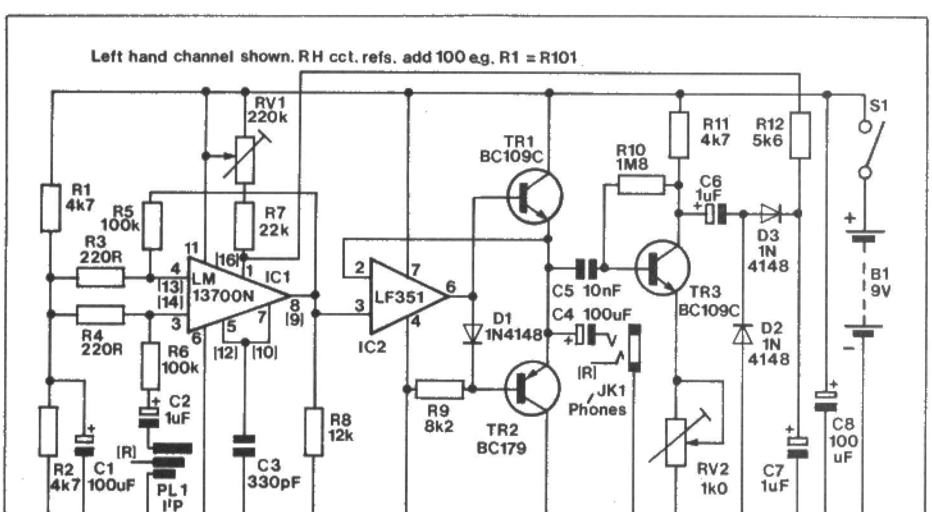


Figure 2. Circuit diagram.

Construction

Refer to figure 3 for details of the printed circuit board. Construction of the board should not be difficult provided the resistors and diodes are fitted first, followed by the capacitors, presets, Veropins, and remaining semiconductors. **Do not** overlook the single link wire. **Also, note** that IC2 has the opposite orientation to the other two ICs.

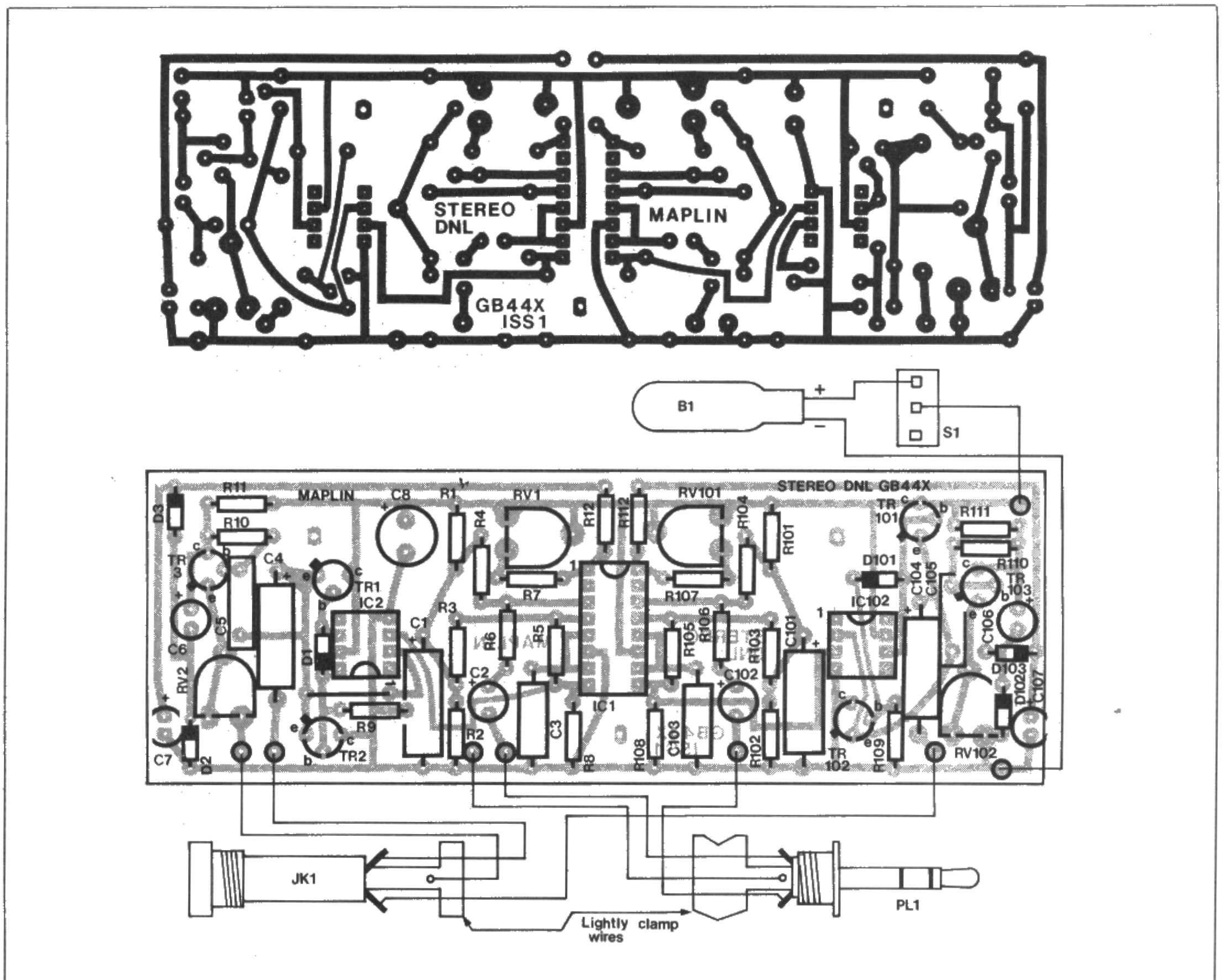


Figure 3. PCB artwork.

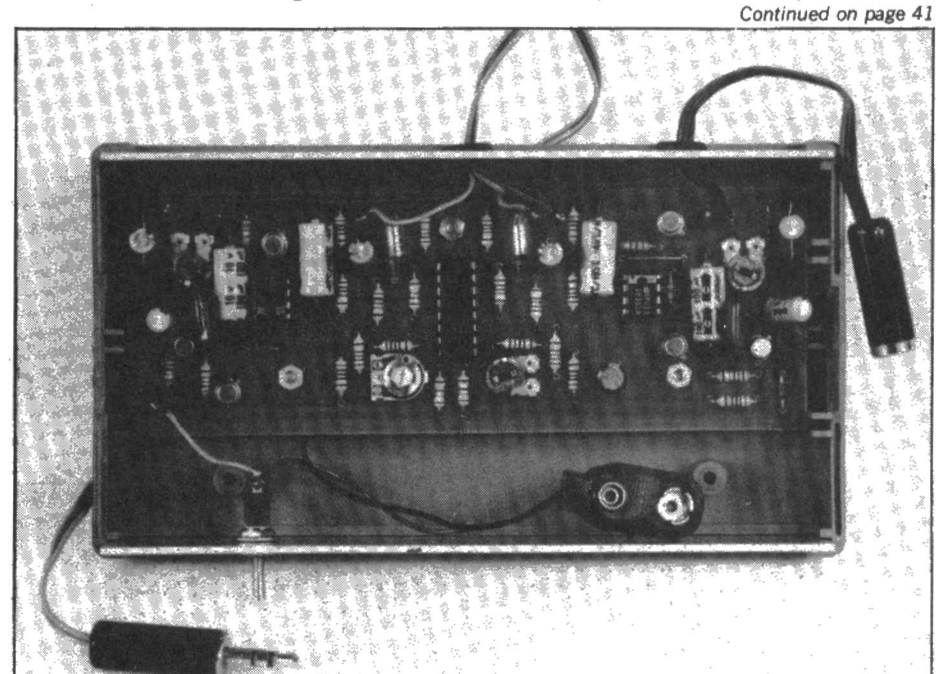
A verocase having approximate outside dimensions of 153 by 84 by 39.5mm makes a neat and practical housing for the unit, but it should be possible to utilise any plastic or metal box of around the same size. The printed circuit board is mounted on the base panel of the case using 6BA fixings. S1 is mounted towards the left hand end of the front panel, and holes for the input and output leads are drilled at the centre and right hand ends of the rear panel. The connection to the headphones is made by way of a short 3 way cable fitted with a 3.5mm stereo line socket. Use of a chassis mounting socket might be a neater solution, but sockets of this type do not seem to be available. The connection to the personal stereo unit is made via a 3 way lead about half a metre or so in length, and terminated in a 3.5mm stereo jack plug. As these leads carry high level, low impedance signals it is not essential to use screened types.

Setting Up

If suitable test gear is to hand, RV1 and RV101 can be adjusted to give a -6dB point a suitable frequency. With this type of equipment a cutoff frequency of somewhere between 4 and 10kHz is normally used, depending on the degree of noise reduction that is required, and 6kHz should be a suitable figure. However, either one leadout wire of D3 and D103 should be temporarily disconnected, or a temporary shorting links should be wired across D2 and D102 so that the test signal does not alter the cutoff frequency of the filter.

Again, if suitable test gear is available RV2 and RV102 can be adjusted to give the desired frequency response with an input signal level that roughly corresponds with maximum volume (about 1 volt RMS). use a test

Continued on page 41



MACHINE CODE PROGRAMMING WITH THE 6502

Part 3

Graham Dixey C.Eng., M.I.E.R.E.

The 6502 addressing modes fall into two broad classes, known as 'non-indexed' and 'indexed'. The difference lies in whether one of the index registers is used in determining the required address. With this definition in mind, it is clear that the modes described in Part Two of this series are all non-indexed modes. So now it is the turn of the indexed modes to be described. The 6502 has four of these, but first a general idea of the topic.

Indexed Addressing

Suppose we wish to load the Accumulator with a number that is in a memory location MEMI on Page 3, say at 0320. Using non-indexed addressing this could be achieved with the absolute addressing mode as follows:

LDA MEMI (Assembly Code) = AD 20 03 (Machine Code)

Now see how it could be done using the X Index Register.

LDX #20 (HEX	A2 20
LDA Base,X	BD 00 03

Believe it or not, this achieves the same object as the program line above i.e. the Accumulator is loaded with the data found at memory location 0320. It works as follows:

The microprocessor decodes the op. code BD and, as a result, knows that the data is to be found at an address given by:

Specified 'base' address (i.e. 0300) + contents of X register (i.e. 20).

Perhaps this seems a long-winded way of getting at the address 0320 but it does have decided advantages as can be seen shortly. Now to be more specific.

Absolute Indexed Addressing

This is the mode just described and so is defined as follows:

Effective Address = Specified two-byte base address (on any page except Page 0) + contents of either X or Y register.

Zero Page Indexed Addressing

This is probably fairly obvious from the previous definition but with a limitation as follows:

Effective Address = Specified single-byte base address (on zero-page) + Contents of X register (except for LDX and STX which use the Y register for indexing).

Note that this mode is restricted to using the X register except for the two specified instructions.

These two modes are termed 'direct' addressing modes because the effective address obtained is actually the address at which the data is found. This compares with 'indirect' addressing where the effective address is not that of the data but merely a further address at which to find the data!

If this seems complicated, then consider the following pigeon-hole analogy.

In the 'direct' case, if you obtain the address of the pigeon-hole and then go to that pigeon-hole, then the number found in it is the data itself.

However, in the 'indirect' case, when you go to the first pigeon-hole, instead of finding the data there you find the address of a second pigeon-hole — and it is at that one that the data is found.

Hopefully, this makes the difference between the two methods clearer; even so, there are two ways of using indirect addressing with the 6502, both of which are restricted to using Page 0 for the 'base address'.

Indexed Indirect Addressing (pre-indexed)

This is shown in Figure 1. Page 0 is said to contain a table of 'pointers', each occupying two consecutive bytes. As the name implies, these point at locations elsewhere in memory at which data are found. For example, the operand for the op. code LDA in this instance is the base address 0080. If the X register initially contains 00, then the 'effective address' is 0080 + 00 which equals 0080, obviously. The microprocessor accesses this memory location AND the next consecutive location (0081) and finds the two bytes that give the address 02C0. It is the data at this latter address that is loaded into the Accumulator. By changing the X register contents in steps of 2, a sequence of memory locations can be accessed by the program.

This method of indexing is not particularly economical on memory space since, for every memory location pointed 'at' on some other page, two memory locations are required on Page 0 as pointers.

Indirect Indexed Addressing (post-indexed)

This is shown in Figure 2. In this case the contents of the Y register are added to an address which is found at two consecutive locations on Page 0. This sum forms a pointer to somewhere else in memory. In the example shown, the LDA instruction has as its operand the address 0080. If the Y register contains 00 initially and the address found at 0080/1 is 02C0, then the effec-

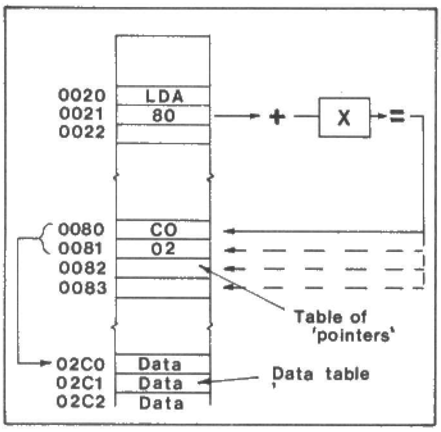


Figure 1. Indexed Indirect Addressing.

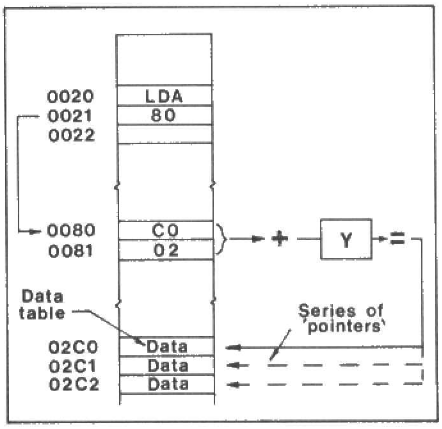


Figure 2. Indirect Indexed Addressing.

MNEMONIC	INDEXED INDIRECT	INDIRECT INDEXED	0 PAGE,X	ABS, X	ABS,Y	INDIRECT	0 PAGE,Y
ADC	61	71	75	7D	79		
AND	21	31	35	3D	39		
ASL			16	1E			
CMP	C1	D1	D5	DD	D9		
DEC			D6	DE			
EOR	41	51	55	5D	59		
INC			F6	FE			
JMP						6C	
LDA	A1	B1	B5	BD	B9		
LDX					BE		B6
LDY			B4	BC			
LSR			56	5E			
ORA	01	11	15	1D	19		
ROL			36	3E			
ROR			76	7E			
SBC	E1	F1	F5	FD	F9		
STA	81	91	95	9D	99		
STX							96
STY			94				

Table 1. Op-codes for the Indexed/Indirect Addressing Modes.

tive address for the data is 02C0 + 00 which is 02C0. If the Y register contents are now successively incremented (increased by 1) or decremented (decreased by 1), a series of memory locations starting at 02C0 can be accessed. This method is obviously much more economical on memory space since, apart from the program itself, only two locations are needed on Page 0 to form as many pointers as are wanted.

The op. codes are given in Table 1 for all instructions that use the indexed modes described.

Note one important exception to the above modes. This is the 'jump' instruction (JMP) which is the only instruction that can use a form of indirect addressing without indexing. This is known as 'absolute indirect' and it works as follows.

The JMP instruction always has a two-byte operand. Suppose it is 031A as an example. At this location and its consecutive location 031B two bytes are found that form an address; it is at this address that the data will actually be found.

Long and Short Branches

Before going on to apply indexed addressing to a program example, it is worth returning to a point that was raised in Part Two of this series. That was the question of branch length which, because of the relative addressing mode that had to be used, was restricted to +127 or -128 steps. This appeared to imply that the length of a branch could not exceed these values, which would obviously be a severe limitation. This is not so; a simple trick shown in the program segment that follows illustrates this.

```
          BNE     SKIP  (avoids the
                        JMP instruction)
          BEQ     JUMP
SKIP      next program line
             |
             |
             |
             |
JUMP      JMP     LONG  (makes a
                  jump anywhere into memory)
```

The crux of this trick is that a JMP instruction uses 'absolute addressing' which can access any area of memory. In the first line a value is tested (say the Accumulator contents) to see whether it equals zero or not. If it doesn't equal zero the program branches to the label SKIP and continues with the main program, whatever that is. However, if this value is found to equal zero, then the program is required to branch to a distant point in memory (i.e. well beyond the +127 or -128 steps permitted by relative addressing). This it does in two steps: the first is a short branch (using relative addressing) to the label JUMP. At the latter location it encounters quite naturally the JUMP instruction which produces the second step; this can be as long as you like, since it uses the absolute addressing mode.

Use of Indexed Addressing

Because indexed addressing uses one of the index registers and because instructions exist which enable the programmer to increment or decrement either X or Y register, it is possible to access a set of data in the form of a table. This could be a 'look-up' table of some known standard values or characters or just a set of input or computed data. The beauty of indexed addressing is that it is possible to access such data sequentially using only a few program lines, even though there may be a substantial amount of data in the table. In fact the number of program lines is quite independent of the number of items in the table. To appreciate this fully, consider the following problem and a way of solving it 'without' the use of indexed addressing.

The problem is that it is required to search through a set of fifty arbitrary numbers and to count the number of times that a certain number appears in that list. Suppose that the number in question is 1E. Then the Assembly Code program might look like this.

```
LDA     MEM1
CMP     #30 (equals 1E in decimal)
BEQ     COUNTER
LDA     MEM2
CMP     #30
BEQ     COUNTER
LDA     MEM3
CMP     #30
BEQ     COUNTER
LDA     MEM4
     etc
```

Details of the counter and the return to main program are not shown but the rest of the program works like this.

The table of values is stored in the memory locations MEM1, MEM2, MEM3, MEM4 ... MEM50. Each is loaded in turn into the Accumulator where a comparison is made (CMP) with the value looked for (1E). The action of the CMP instruction is to subtract the specific value (1E in this case) from the Accumulator contents and to condition the N, Z and C flags in the Status Register according to the result. For example if A ⩾ DATA then C is SET; if A = DATA then Z is SET, and so on. A branch test is used to establish the result and cause the program to diverge to the counter loop: In this case, we are looking for equality and so the BEQ test is used. This will obviously work but look at the length of program required! Fifty items to test will need 150 program lines or 300 bytes (at least).

Now compare this with indexed addressing.

```
        LDX   #00 (initialise X register)
START   LDA   BASE, X (load an item)
        CMP   #30
        CMP   #30 (test its value)
        BEQ   COUNTER (go to counter if
              if value found)
        INX   (increment X register)
        CPX   #50 (tested all 50 items?)
        BEQ   FINISH (exit loop and stop
              testing)
        JMP   START (otherwise go round
              again)
          |
          |
          |
FINISH  BRK   (end of test).
```

This program (again omitting the counter) is otherwise complete for testing a block of 50 consecutive values of data. In fact, by changing the operand for the CPX instruction any length block up to a maximum of 255 bytes can be tested. In the first program line the X register is set to its initial value, which will usually be zero. This means that when, on the next line, the Accumulator is loaded from BASE+ X, it will actually be loaded from the base address itself, since X = 0. The CMP instruction compares the loaded value with the required value 1E (written in decimal in Assembly Code as a matter of protocol i.e. 30). A BEQ test finds out whether the required value has been found in the same manner as in the previous non-indexed program, in which case the counter is notched up or otherwise. The INX instruction increases the contents of the X register by ONE, to 01, so that the next loading of the Accumulator will be made from the next consecutive location in the memory block i.e. from BASE + 01. However, because the data block is of a specified length (50 bytes in this case) it is necessary to terminate the program when exactly this number of bytes have been tested. This is done with a further comparison test (X-50) and a BEQ which branches out of the program to the 'break' instruction (BRK) when 50 is reached. Otherwise the program keeps branching back to START and testing new data.

This is an example of a typical loop in which the X register functions as a counter in order to keep a note of the number of times we go round the loop and to allow us to exit at the right moment. In this particular case, the X register performs a dual role, as the counter just described and as an index for zero-page indexed addressing.

Obviously addressing modes need regular practice in order to use them efficiently, more than can be given in an article of this sort. However, hopefully by now enough has been done so that, in future programs, when various addressing modes are used, they will be fairly readily recognised. Next time we shall look at input/output techniques in some detail and explain how to write programs that will act on input data and provide useful outputs to the outside world.

continued from Page 30

balance current between the live and neutral poles to trip the circuit breaker. The other is the voltage operated type, where the earth leakage current flows through the trip coil of the ELCB, energises it, and causes the ELCB to trip.

The major role of the ELCB is to protect an installation from earth leakage, and to isolate it from the mains when a fault occurs (as does a fuse, which blows when a live conductor is in contact with earthed metalwork). ELCBs were fitted where there was no conventional earthing provided by the electricity board. The ELCB operates in conjunction with an earth rod, and is necessary because sometimes the resistance of the earth path back to the electricity supply system is too high to allow sufficient earth leakage current to operate a fuse or an mcb. The ELCB requires only a small current to trip it. The current operated ELCBs are the more reliable but earlier models required up to 1 amp to trip and were suitable only where the soil in the earth fault path was of low resistance.

Where as is usual the resistance is 40 ohms or more a voltage operated ELCB had to be installed.

In recent years the high sensitivity current operated ELCB has been developed. These have a trip current rating which can be as small as 30milliamp though domestic circuits utilise those having trip current ratings of 30mA and 100mA. The current operated ELCB has been renamed "Residual Current Device" (RCD) and the voltage operated type has been renamed "Voltage Protected Device" (VPD).

Protection from electrocution

An RCD having a trip current rating of 30mA and operating at less than 30 milliseconds will normally protect a person from electrocution, should they come into accidental contact with a live conductor, or live unearthed metalwork. As already stated a socket outlet used to supply a lawnmower, hedgetrimmer or other tool or appliance outdoors should be protected by an RCD of 30mA trip rating. The RCD can be incorporated in the socket assembly, or supply the circuit of socket outlets, or be of the 13A fused plug type which is connected to the flex of the appliance in place of the conventional fused plug.

Alternatively it can be connected on the end of a short extension lead and the trailing plug used for plugging in various tools and appliances, without the need to change the RCD plug as a different tool is used.

Safety

Although some 15 million homes throughout the U.K. are supplied with electricity, electrocution fatalities are usually below 80 per year. This low figure can be attributed to the high quality fittings and accessories available nowadays. Many electrical accidents (fatal or otherwise) can be put down to carelessness. The householder having D.I.Y. experience, and conscientiously using high quality cables and fittings need have no fear that the job will be unsafe and will be of a standard acceptable by the electricity board, if they follow the guidelines presented in this article. Do take care when installing wiring, and only use specified fittings conforming to relevant British Standards.

Bathrooms present one of the most hazardous areas in the home. Extreme care, with careful regard to purchasing the right fittings designed for bathrooms, will ensure maximum safety for the occupant.

Great care should be exercised when installing exterior wiring — always ensure that cables are routed correctly, avoiding obvious hazards, and always fit weatherproofing covers to exposed sockets.

Further reading material is listed at the end of this article, should the reader wish to refer to other details. It must be stressed that if any doubts exist regarding one's ability to rewire, a competent, qualified electrician should be consulted.

Further reading

"Home Electrics" by Geoffrey Burdett (RQ 22Y). "Q and A on Electric Wiring" by W. Turner (RL 29G).

Obituary

We would like to express our sincere condolensces to Geoffrey Burdett's family, following his sudden death.

We also wish to express our thanks for their kind permission to allow publication of the second part of this article.

Personal Stereo DNL *Continued from page 38*

signal at a frequency of a few kilohertz.

It is not essential to have any test equipment in order to set up the unit satisfactorily, and RV1/101 can simply be adjusted to give the desired amount of noise reduction, being careful to keep the two stereo channels well balanced in this respect. Do not be tempted to set these controls for a very high level of noise reduction as this would give a very poor frequency response at low signal levels, and the changes in frequency response would be so large that they would probably be clearly audible to the user.

RV2 and RV102 can simply be set by trial and error. If these are set at or near minimum resistance the filtering will be lifted even at quite low dynamic levels, and this will be heard as a rise and fall in the noise level as the input signal rises and falls in amplitude. RV2 and RV102 should be advanced to the point where this effect is no longer apparent on their respective channels, but not significantly further than this.

The setting of the volume control on the personal stereo unit obviously has an effect on the way in which the DNL performs. When setting up the unit the volume control should be at a fairly high setting. The DNL will then function properly when the system is used at fairly high volume levels, but will function more or less as a straight forward top cut filter if the system is used at low volume settings. In practice tape noise is generally only objectionable when listening at high volume levels, and it would not be worthwhile using the unit at low volume settings anyway. The DNL has nominally unity voltage gain, and there should not be any appreciable change in volume when it is used.

The unit will work with the tone switch on the personal stereo unit in either the "high" setting or the "low" one, but results will probably be best with this control in the "high" position. If this gives excessive treble at high signal levels backing off RV2 and RV102 slightly should clear the problem.

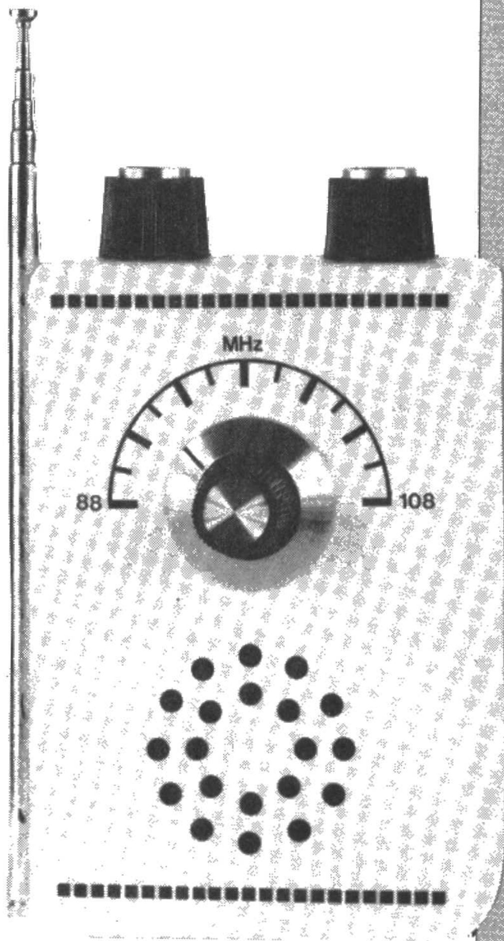
PERSONAL STEREO DNL

Resistor — All 0.4W 1% metal film			
R1,2,11,101,102 111	4k7	(6 off)	(M4K7)
R3,4,103,104	220R	(4 off)	(M220R)
R5,6,105,106	100k	(4 off)	(M100K)
R7,107	22k	(2 off)	(M22K)
R8,108	12k	(2 off)	(M12K)
R9,109	8k2	(2 off)	(M8K2)
R10,110	1M8	(2 off)	(B1M8)
R12,112	5k6	(2 off)	(M5K6)
RV1,101	220k hor. preset	(2 off)	(WR62S)
RV2,102	1k0 hor. preset	(2 off)	(WR55K)
Capacitors			
C1,4,101,104	100uF 10V axial electrolytic	(4 off)	(FB48C)
C2,6,7,102 106,107	1uF 100V P.C. electrolytic	(6 off)	(FF01B)
C3,103	330pF polystyrene	(2 off)	(BX31J)
C5,105	10nF polyester	(2 off)	(BX70M)
C8	100uF 10V P.C. electrolytic		(FF10L)
Semiconductors			
IC1,	LM13700N		(YH64U)
IC2,102	LF351	(2 off)	(WQ 30H)
TR1,3,101,103	BC109C	(4 off)	(QB33L)
TR2,102	BC179	(2 off)	(QB54J)
D1,2,3,101,102, 103	1N4148	(6 off)	(QL80B)
Miscellaneous			
S1	SPST Ultra min toggle		(FH97F)
PL1	3.5mm stereo plug		(HF98G)
JK1	3.5mm stereo line skt.		(RK51F)
B1	PP3 9V		
	Printed circuit board		(GB44X)
	Veropins 2145	1 Pkt	(FL24B)
	Ribbon cable 10-way	1 mtre	(XR06G)
	PP3 clip		(HF28F)
Optional			
	Case		(LL08J)

A kit of parts (excluding case) is available.
Order As LK27E Price £8.40

TDA 7000 RADIO

by Robert Penfold



★ USES IMAGINATIVE MULLARD IC
★ NO ALIGNMENT EQUIPMENT NEEDED
★ EASY TO BUILD

Conventional Band II VHF superhet radios use a large number of tuned circuits as these are needed for filtering in the RF, mixer, oscillator, IF, and detector stages. Ceramic filters have become very popular in recent years, but these can only replace one or two IF transformers, and only marginally ease problems with alignment of the finished receiver. The TDA7000 is a new and imaginative integrated circuit from Mullard which employs novel techniques that enable a good quality FM broadcast receiver having just two tuned circuits to be built. The reason for this device being developed is that it offers radio manufacturers the advantages of reduced costs, both in terms of components and the setting up time for the finished receiver. For the home constructor it similarly gives the advantages of low cost and ease of alignment. In fact the finished receiver only needs to have the core of one tuned circuit adjusted to give the correct frequency coverage, and no test gear is required. A TDA7000 FM radio is actually no more difficult to align than a simple SN414 based AM radio!

Low IF

Strictly speaking the basic system used in the TDA7000 is not a new one, and is essentially the same as that used in the so called "pulse counting" FM tuner designs that were popular amonst home constructors around twenty years ago (the original designs used valves)! The block diagram of Figure 1 shows the way in which these operate. The RF, mixer, and osciallator stages are fairly conventional, but usually quite simple with just a broadband (preset tuning) filter ahead of the mixer, but a more complex arrangement could be used if preferred. It is at the IF and demodulator stages where the real departures from a conventional superhet arrangement occur. The IF amplifiers are virtually ordinary high gain audio amplifiers, but filter capacitors are used to roll-off the response above about 200kHz and the coupling capacitors only need to be effective at frequencies above the audio range. This gives an IF centred at around 100kHz or so, and not tuned circuits to provide IF filtering are required. The low IF enables simple C-R filtering to give adequate results, and thre is no lack of performance in this respect. A pulse counting circuit plus an RF filter provides the demodulation, and the pulse counter is merely a diode-pump frequency-to-voltage converter. Other types of circuit such as a phase locked loop or even just a monostable multivibrator can be used here to convert the frequency variations into the corresponding audio signal. While this system has obvious attractions, it is not without its drawbacks as well. The main one is the lack of any image rejection, due to the very low IF and the spacing of only a few tens of Kilohertz between what would normally be the main and image responses. Thus, when tuning a receiver of this type there are two very closely spaced points on the tuning dial where each station can be received satisfactorily, with a very narrow gap between these where the station is received, but is

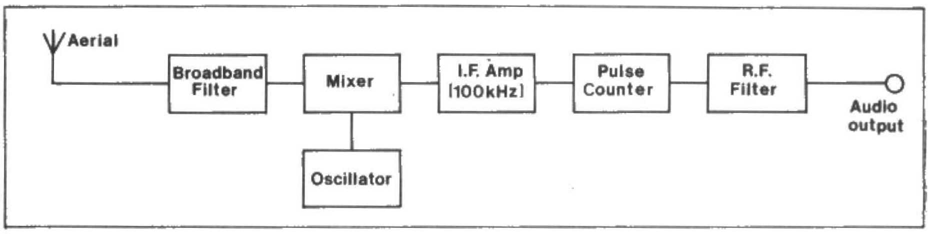


Figure 1. Block diagram

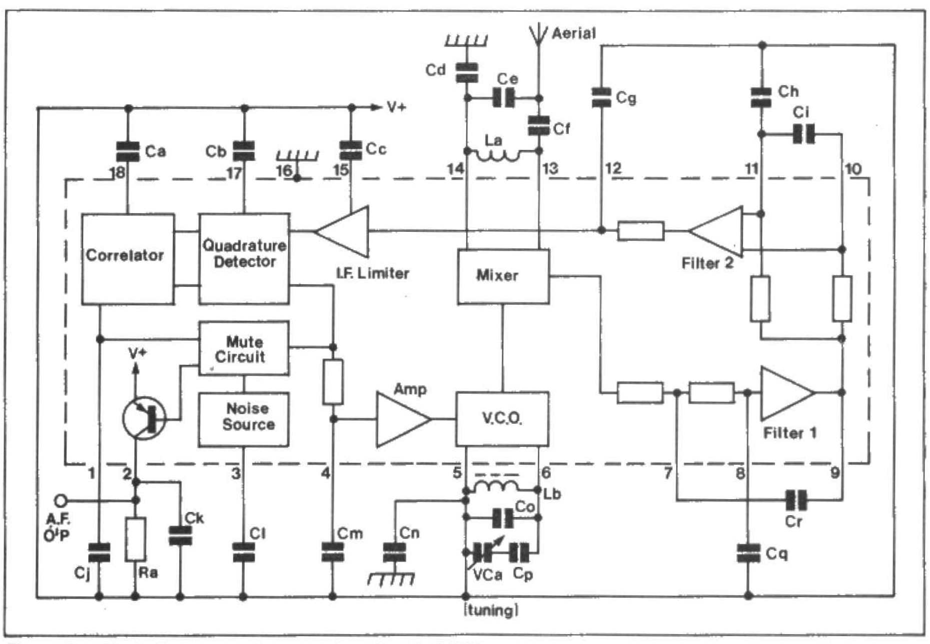


Figure 2. Block diagram and connections for TDA7000

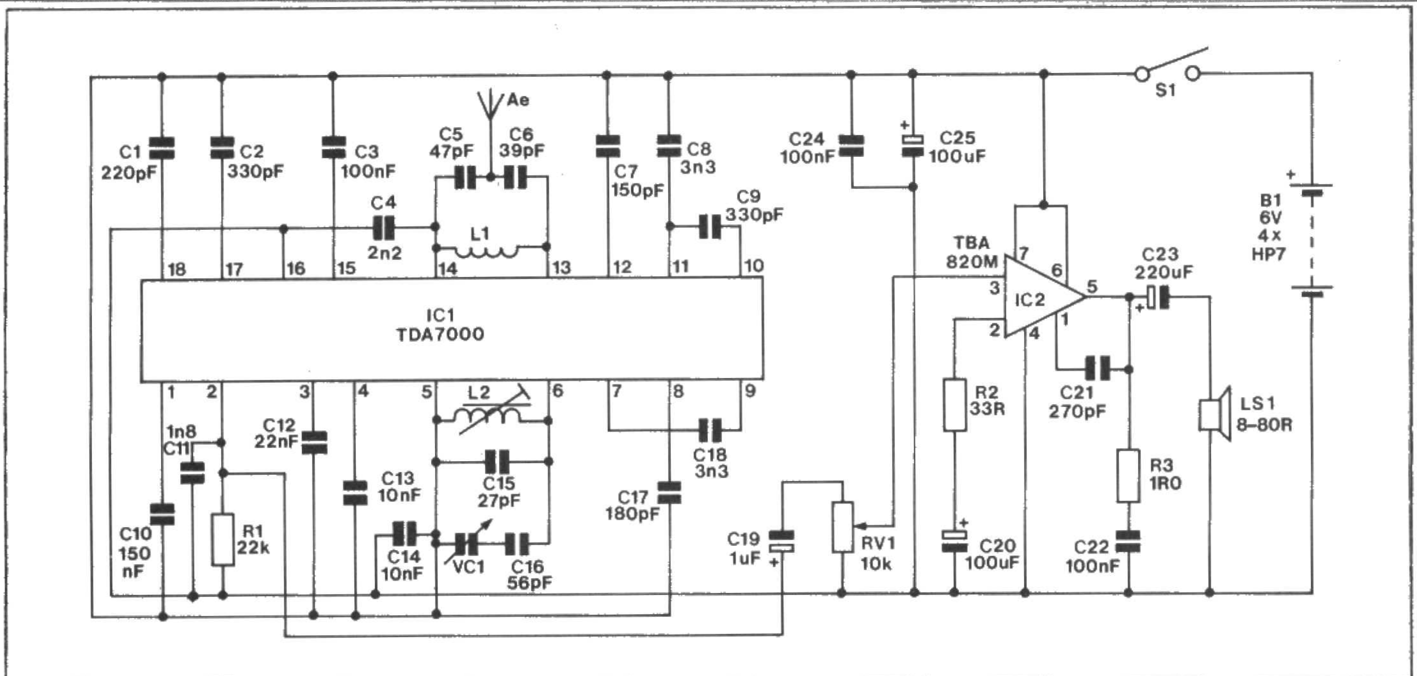


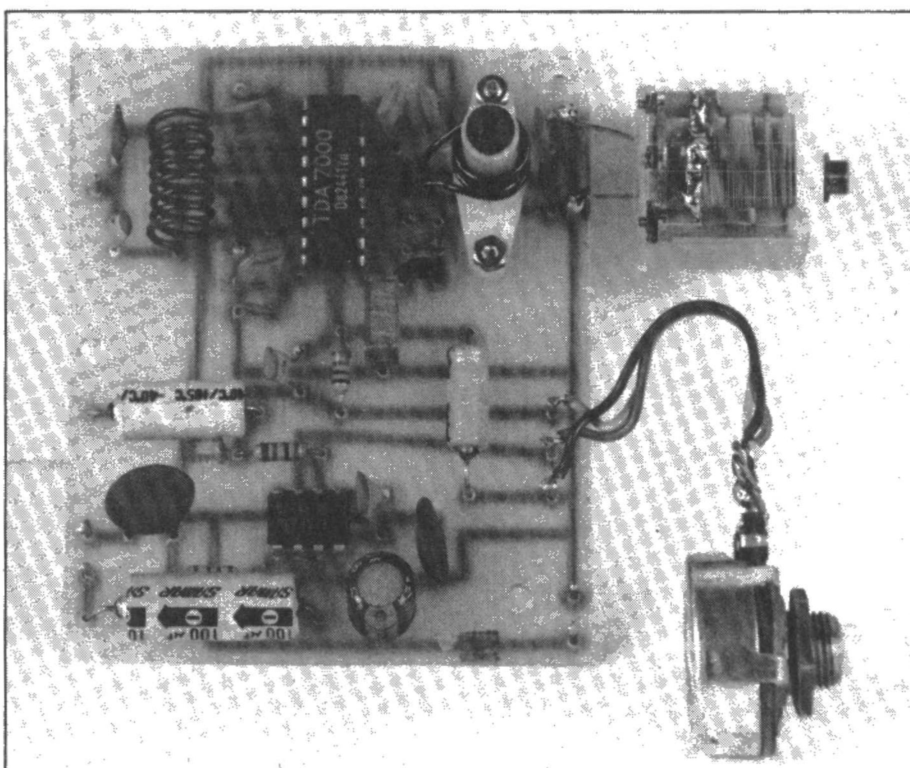
Figure 3. Circuit diagram of TDA7000 radio

very severely distorted. As Band II FM broadcast stations tend to be well spread out this is unlikely to give problems with co-channel interference, but does make tuning the set a little awkward.

TDA7000

Although pulse counting tuners were originally conceived as simple alternatives to conventional circuits, it would not be accurate to think of the TDA 7000 as providing an inferior alternative to a conventional design. It uses a highly refined version of the pulse counting type of circuit, and in some respects it is superior to more conventional designs. Figure 2 shows the arrangement used in this device, plus basic details of the discrete components required. The standard TDA7000 has an 18 pin DIL plastic package, but there is also a minature 16 pin version, the TDA7000T. The input tuned circuit is formed by La, Ce, and Cf. Internal resistors of the TDA7000 heavily damp this filter so that it has a very wide bandwidth and no RF tuning is needed. La can in fact be a zig-zag of printed circuit track, but in the design featured here it is a simple home-made coil. The aerial, which is a simple wire or telescopic type, is coupled to the input tuned circuit by way of a capacitive tapping. A voltage controlled oscillator feeds the other input of the mixer stage. This VCO is a straight forward L-C type which achieves voltage control using a couple of variable capacitance diodes. There are three IF filter stages,and the first of these uses a second-order low pass Sallen-Key circuit, which is the type of filter used in scratch filters and similar applications. Cq and Cr are the filter capacitors, but the filter resistors and other components are part of the TDA7000. The second filter is a simple bandpass type, and again, the only discrete components are two capacitors. The final filter stage is a straight forward passive first-order lowpass type which uses discrete capacitor Cg. The reason for using discrete rather than on-chip filter capacitors is simply that it is difficult and expensive to include even low value capacitors in an integrated circuit. The -60dB bandwidth of the filters is approximately 500kHz, which is perfectly adequate for an FM broadcast receiver.

After filtering the signal is amplified and limited in the usual way, and demodulated by a quadrature detector. Unlike a standard 10.7MHz quadrature detector, no tuned circuit is required, just on phase shift capacitor (Cb). The intermediate frequency can be set at any reasonable figure by using the appropriate filter capacitor values, but a frequency of 70kHz would normally be used. Such a low IF eliminates any problems with the image signal of one channel interfering with reception of a transmission on the next channel. With the set tuned to one channel the image response falls roughly half-way between this channel and the next. The problem of using such a low IF is that it would result in severe distortion with signals having something approaching the full plus and minus 75kHz deviation. This problem is overcome by amplifying the audio output signal and feeding it to the VCO. This gives a form of negative feedback with the VCO following the input signal up and down in frequency. The deviation of the VCO is not quite equal to that of the input signal so that there is some variation in the frequency of the IF signal, but this is only about plus and minus 15kHz. The typical total harmonic distortion on the audio output is 2.3% at maximum deviation, which is satisfactory for portable radios and similar applications. A useful "byproduct" of the feedback to



the VCO is that it gives a sort of automatic frequency control. Apart from counteracting any tuning drift, this effectively gives slow-motion tuning once the receiver has locked onto a transmission, and makes the set easy to tune even if only a small tuning knob is used.

Correlator

The correlator and mute circuits of the TDA7000 are used to suppress the image response as well as giving a conventional "squelch" action. The correlator operates by delaying the IF signal by an amount equal to the duration of one IF half cycle. This signal is then inverted and compared with the unprocessed IF signal. If the tuning is correct, the two signals will be virtually identical and will have a high degree of correlation. However, if the tuning is not very accurate the IF signal will be displaced from its normal 70kHz figure, and the delaying circuit will not give a one half cycle delay. This introduces a phase difference and poor correlation, with the mute circuit switching vf the audio in consequence. If the IF signal is noise, or largely consists of noise, this also gives very little correlation between the two signals and mutes the audio output. An interesting effect of this system of muting is that it eliminates the side responses that are normally found on FM radios. These are caused by the signal being "slope" detected by the skirt responses of the IF filtering, and they can make accurate tuning a little difficult. Many FM radios have a tuning indicator to assist proper tuning. The TDA7000 muting system eliminates the side responses, and together with the frequency locking tuning system makes tuning very easy indeed. A detuning indicator can be driven from pin 1 of the TDA7000, but in practice it would be pointless to do so.

On its own the correlator does not eliminate the image response, but it does so in conjunction with the feedback to the VCO which was described above (the frequency locked loop or FLL) as the IC manufacturer terms it). This locking system only operates with the set tuned to the main response, and not when it is tuned to the image, due to the inversion of the signal that occurs. If we take a simple mathematical example to demonstrate this point, let us suppose that the receiver is tuned to a transmission which deviates between 100 and 101MHz, and that the oscillator is at 99MHz. This gives an IF range of 1 to 2MHz (100 - 99MHz and 101 - 99MHz). Of course, these figures have been chosen for their mathematical simplicity, and are not meant to be practical examples. As the IF signal moves up and down in frequency the audio output voltage also rises and falls, feeding a control voltage to the oscillator that shifts its frequency in the same direction as the input signal. The image response would occur with the oscillator at 102MHz, giving an IF range of 2 to 1MHz (102 - 100MHz and 102 - 101MHz). This frequency inversion of the if signal appears as a phase inversion of the

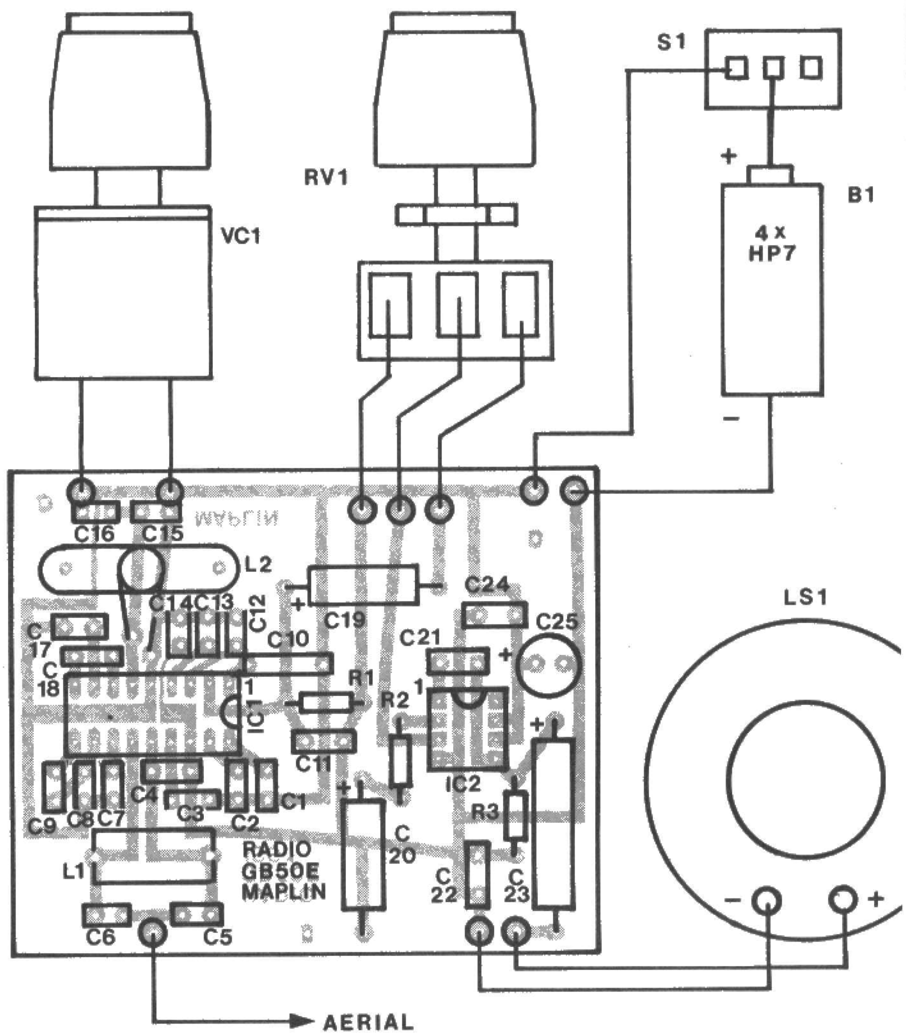


Figure 4. Circuit board layout

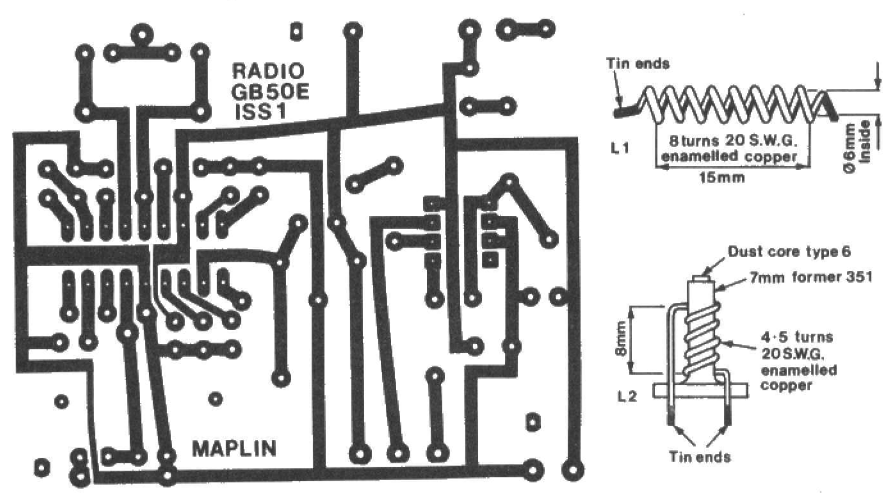


Figure 5. Coil details

audio output signal. Where the oscillator frequency was previously taken high er and lower in sympathy with the received signal to effectively reduce the level of deviation, when tuned to the image response it is moved in the opposite direction so that the deviation is effectively increased. For example, with the input signal at 100MHz the IF signal is at 2MHz, giving the maximum audio output voltage. This sends the oscillator higher in frequency, giving an even greater IF signal frequency, greater audio voltage, and positive rather than negative feedback. When tuned to the image the IF signal does repeatedly pass through the acceptable IF range, but the value of Cj is chosen to give the muting circuit a slow response time so that it ignores these transients, and the image is suppressed. Ra is the load resistor for the audio output stage, and Ck is the de-emphasis capacitor. A slightly bizarre feature of the TDA7000 is a noise generator which gives a quiet noise signal at the audio output when the main audio signal is muted! This is included because it is otherwise very easy to tune over a station without realising it is there. The null in the noise signal as the

set is tuned through a station helps to avoid this. However, if desired the noise can be eliminated by omitting C1.

The Circuit

Figure 3 shows the circuit of a practical radio built around the TDA7000, and the circuitry associated with IC1 exactly follows the arrangement shown in Figure 2 and discussed earlier.

An audio output stage using a TBA820M (IC2) is included, and this will operate with any loudspeaker having an impedance in the range 8 to 80 ohms. An output power of about 300 milliwatts RMS into an 8 ohm loudspeaker is available, and this is adequate for a portable radio. The output stage will also drive any normal type of earphone or headphones. VR1 is an ordinary volume control.

Construction

A suitable printed circuit layout for the radio appears in Figure 4. The TDA7000 is not one of the many radio ICs that tend to be unstable at every opportunity, and the low IF eliminates problems with harmonics of the clipped IF signal being picked up at the input of the circuit. However, with frequencies in the region of 100MHz involved it is not advisable to use a different layout unless you are familiar with radio projects and know exactly what you are doing. The only unusual aspects of construction are the two home-wound coils. L1 is the more simple of the two, and consists of 8 turns of 20 swg enamelled copper wire wound or a temporary former about 6 to 6.5mm in diameter. A twist drill of about this size or a potentiometer spindle can be used as the former. The coil is about 15mm in length, but as it is used in a broadband filter its exact characteristics are not critical. L2 is wound on a 7mm diameter coil former which is bolted to the board using M2 fixings. It consists of about 4.5 turns of 20 swg enamelled copper wire and the winding should be approximately 8mm in length. Again, the precise characteristics of the coil are not highly critical, and in this case it is because the former is fitted with an iron dust core that enable the inductance to be adjusted over a fairly wide range. An important point to bear in mind is that the leads which connect VC1 to the board must be very short, and should preferably be only about 10 to 30mm long. Be careful to connect VC1 the right way round or hand-capacity effects will make tuning practically impossible. (See Figure 6 for details on connecting VC1). Power is obtained from four HP7 size cells fitted in a plastic battery holder. The holder connects to the board by way of an ordinary PP3 style battery connector.

For best volume from the set it is advisable to use an 8 ohm impedance loudspeaker of reasonable size, and a 76mm diameter type is ideal. The unit can be fitted in a metal or plastic case, but a plastic type is probably the best choice as it will not have a detuning effect on the two tuned circuits. Also, with a plastic type there is no need to insulate the telescopic aerial from the case. Ideally the aerial should be a fairly long type having a swivel base, but satisfactory results can be achieved using a small non-swivel type, or even just a piece of wire about 0.5 to 1 metre long.

Adjustment

Only the core of L2 needs to be adjusted before the set is ready for use. This is just a matter of finding by empirical means a setting that enables the entire VHF Band II to be tuned using VC1. In fact any setting that enables all the desired stations to be received is acceptable. It is a good idea to glue the winding and core to the former so that this coil is as rigid as possibie. This helps to avoid problems with microphony, and prevents vibration from gradually detuning L2. It is possible to peak the sensitivity of the set by bunching the turns on L1 together, or spreading them apart, to alter its inductance. Due to the very wide bandwidth of this tuned circuit it is unlikely that this would produce a significant boost in performance though.

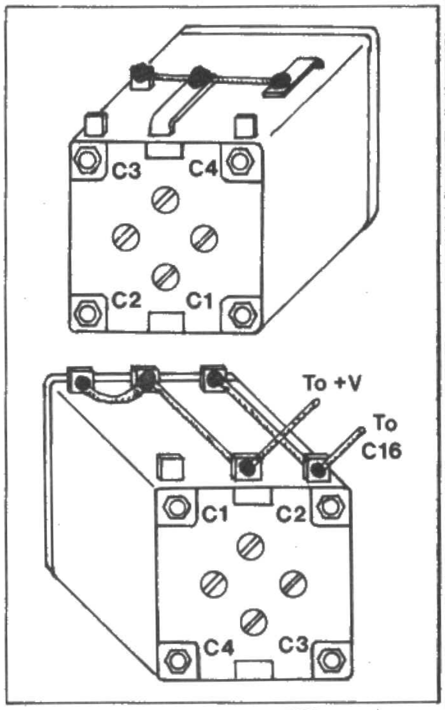


Figure 6. Connections made on VC1

TDA7000 RADIO

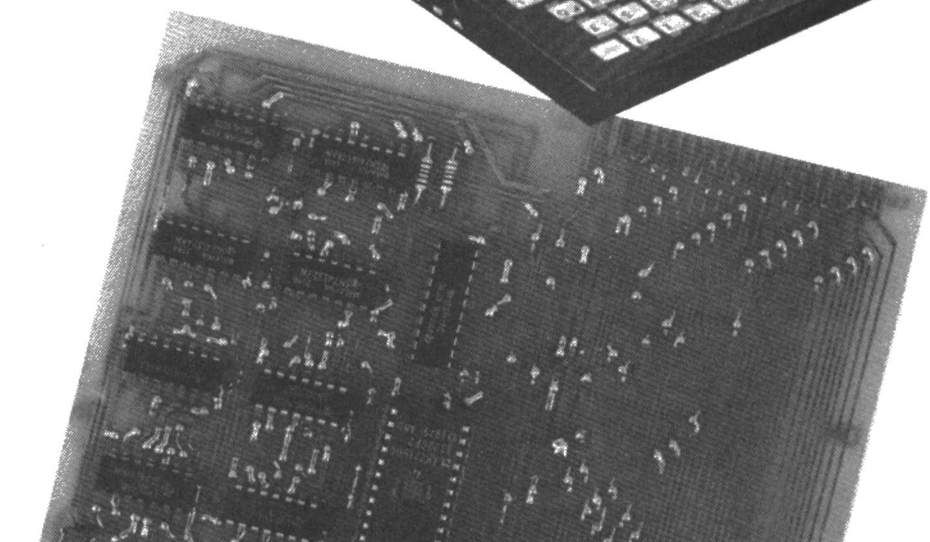
Resistors — All 0.4W 1% metal film

R1	22k		(M22K)
R2	33R		(M33R)
R3	1R0		(M1R0)
RV1	10k Pot log		(FW22Y)
Capacitors			
C1	220pF ceramic		(WX60Q)
C2,9	330pF ceramic	(2 off)	(WX62S)
C3,22,24	100nF minidisc	(3 off)	(YR75S)
C4	2n2F ceramic		(WX72P)
C5	47pF ceramic		(WX52G)
C6	39pF ceramic		(WX51F)
C7	150pF ceramic		(WX58N)
C8,18	3n3F ceramic	(2 off)	(WX74R)
C10	150nF Polycarbonate		(WW43W)
C11	1n8F ceramic		(WX71N)
C12	22nF ceramic		(WX78K)
C13,14	10nF ceramic	(2 off)	(WX77J)
C15	27pF ceramic		(WX49D)
C16	56pF ceramic		(WX53H)
C17	180pF ceramic		(WX59P)
C19	1uF63V axial electrolytic		(FB12N)
C20	100uF10V axial electrolytic		(FB48C)
C21	270pF ceramic		(WX61R)
C23	220uF10V axial electrolytic		(FB60Q)
C25	100uF10V P.C. electrolytic		(FF10L)
VC1	AM/FM Varitune		(FG75S)
Semiconductors			
IC1	TDA7000		(YH87U)
IC2	TBA820M		(WQ63T)
Miscellaneous			
S1	SPST Ultra min toggle		(FH97F)
B1	Four HP7 cells		
LS1	8R L/S LO-Z 768		(YW53H)
	Printed circuit board		(GB50E)
	Control knob K7B	(2 off)	(YX02C)
	20 swg enamelled copper		(BL26D)
	Wire (½ metre)		
	Former 351		(LB17T)
	Core type 6		(LB42V)
	Bolt M2 x 6mm	1 pkt	(BF41U)
	Nut M2	1 pkt	(LR59P)
	Veropins 2145	1 pkt	(FL24B)
	Wire		(BL00A)
Optional			
	Battery holder		(HF29G)
	Battery clip		(HF28F)
	Case (as required)		
	Aerial (as required)		

A complete kit of parts, excluding case, aerial, battery holder and clip is available.
Order As LK32K (TDA 7000 Radio Kit) Price £11.70

EXTRA HIGH RESOLUTION GRAPHICS For the ZX81

- ★ Full 256 x 192 fine pixel display with normal/inverted video
- ★ Draws lines, circles and triangles, fills and textures.
- ★ Up to 32 user defined graphics
- ★ Operates directly from extended Basic



A high resolution graphics module designed for the ZX81 with 16K-64K RAM availability. Access to the HI RES screen is made from extended basic commands such as SLOW n, FAST n, CLS n, and PLOT n,x,y which produce a 256 x 192 pixel display and keeps programming very simple for the operator. PRINTing to any pixel on the High Res screen enables characters, numbers or letters to be placed at will on the display, and both HI/LO RES screen's can be SAVED, LOADED or COPYed from BASIC.

How It Works

The module requires a minimum of 8K RAM connected externally (see Fig. 3) and also, the Sinclair 1 K RAM is used to store variables used by graphics routines and user defined character tables. The RAM is made to appear twice in memory map from 8K to 10K and IC 4,5,7 and 8K. ICII provides 2K of ROM containing graphics routines, which are pre-programmed, and appear in memory between 10K and 12K. A list of new variables appears further on, along with "routine" entry points and RAM areas useful for storing machine-code programs. The HI-RES display file is stored in a Basic program line at the end-of-program area. Being set up automatically, it moves around in memory as Basic lines are added or deleted, but is ignored by the computer as two newline characters (118) immediately follow the line number. Each row of pixels, are mapped from 34 bytes in the display file and 8 bits of each byte, map to 8 successive pixels on the screen (left most significant). Rows follow straight on from one another (top to bottom of the display) without any newline characters at the end of each row.

Note that these variables are initialised only after the first HI-RES statement. Those marked ★ should not be poked at any time.

Construction

Refer to the parts list for component designations.

The module is quite easy to construct and track "throu" pins are used instead of wire links. These pins join tracks together on both sides of the PCB, and therefore should be soldered to each side. Insert track pins into all holes, marked with a circle on side A, 226 are required so keep count as you go. Push the head of each pin firmly down to the board with a soldering iron before applying solder. It is important to watch out for solder splashes and bridging across

SYSTEM VARIABLES

BYTES	ADDRESS	CONTENTS
2	896Ø	OFF-SET OF HI-RES DISPLAY FILE ADDRESS, LESS 9, FROM THE "D-FILE" VARIABLE
2	8962	NOT USED
2	8964	START ADDRESS OF LAST LINE OF LO-RES DISPLAY FILE
2	8966	START ADDRESS OF HI-RES DISPLAY FILE, LESS 9 (Used for video)
2	8968	START ADDRESS OF HI-RES DISPLAY FILE
2	897Ø	BYTES DEFINING TRIANGLE TEXTURE
2	8972	CHARACTER TABLE ADDRESS FOR CHR$ Ø-63
2	8974	CHARACTER TABLE ADDRESS FOR CHR$ 128-159
2	8976	VECTOR FOR ADDITIONAL PLOT ROUTINES
3 ★	8978	FLAGS
2	8981	ADDRESS OF USER-DEFINED-CHR$ TABLE (LESS 256)
1	8983	"READ-POINT" BYTE. NOT ZERO IF PIXEL IS SET
1 ★	8984	DISPLAY HEIGHT (NORM 192)
1	8985	FLAGS
7	8986	TEMPORARY VARIABLES FOR PLOT ROUTINE
1	8993	PLOT OUT OF RANGE FLAT. BIT 7 = LATEST STATEMENT
1	8994	NOT USED
2	8995	X-COORDINATE FOR PLOT (SIGNED 16 BIT NUMBER)
2	8997	Y-COORDINATE
8	8999	X AND Y COORDINATES FOR PREVIOUS 2 PLOT STATEMENTS
1	9ØØ7	FLAGS
4	9ØØ8	X AND Y COORDINATES OF GRAPHICS ORIGIN
4	9Ø12	BYTES DEFINING 4 LINE TYPES
2	9Ø16	TEMPORARY VARIABLES FOR PLOT

System Variables

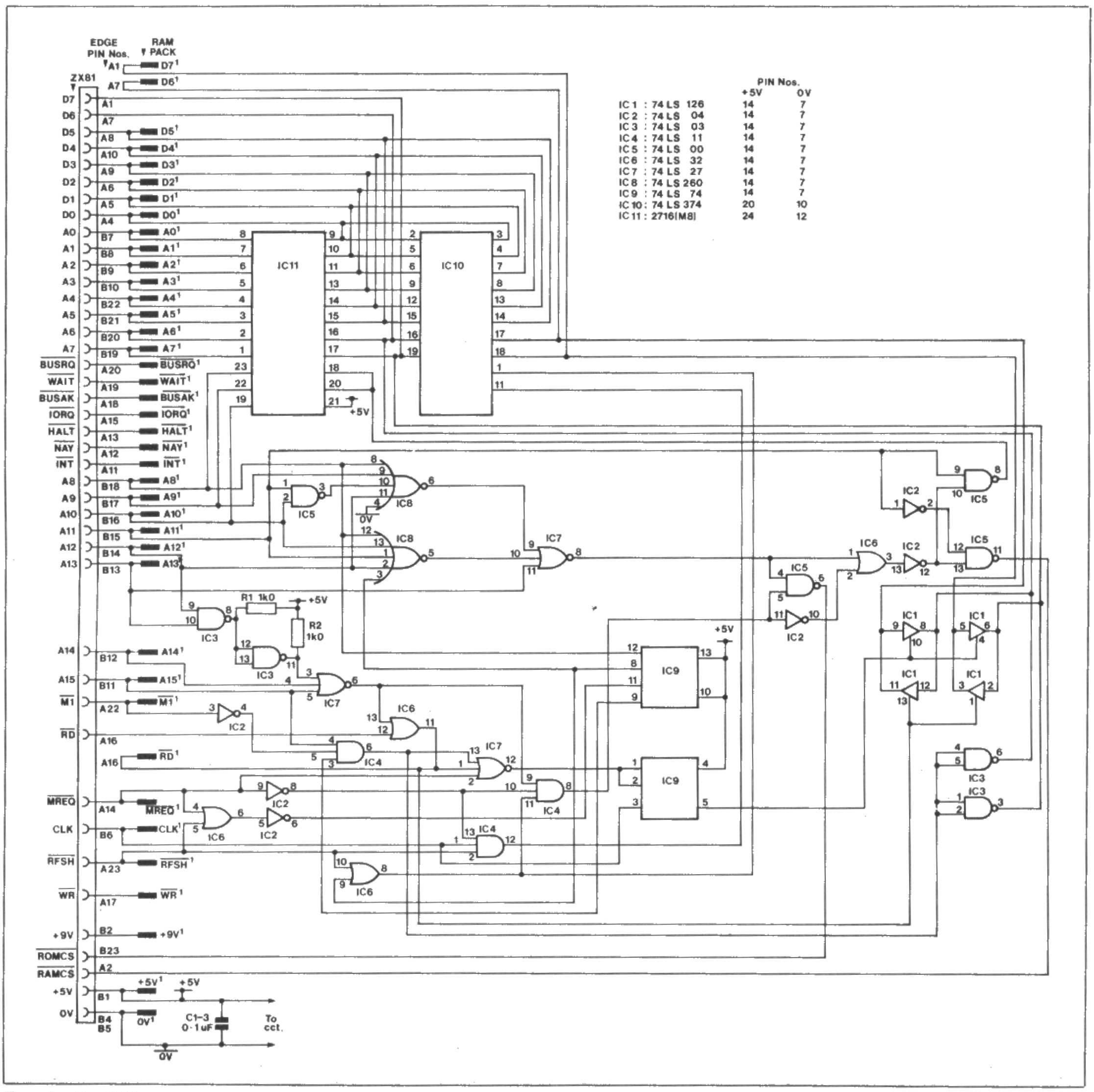


Figure 1. Circuit Diagram.

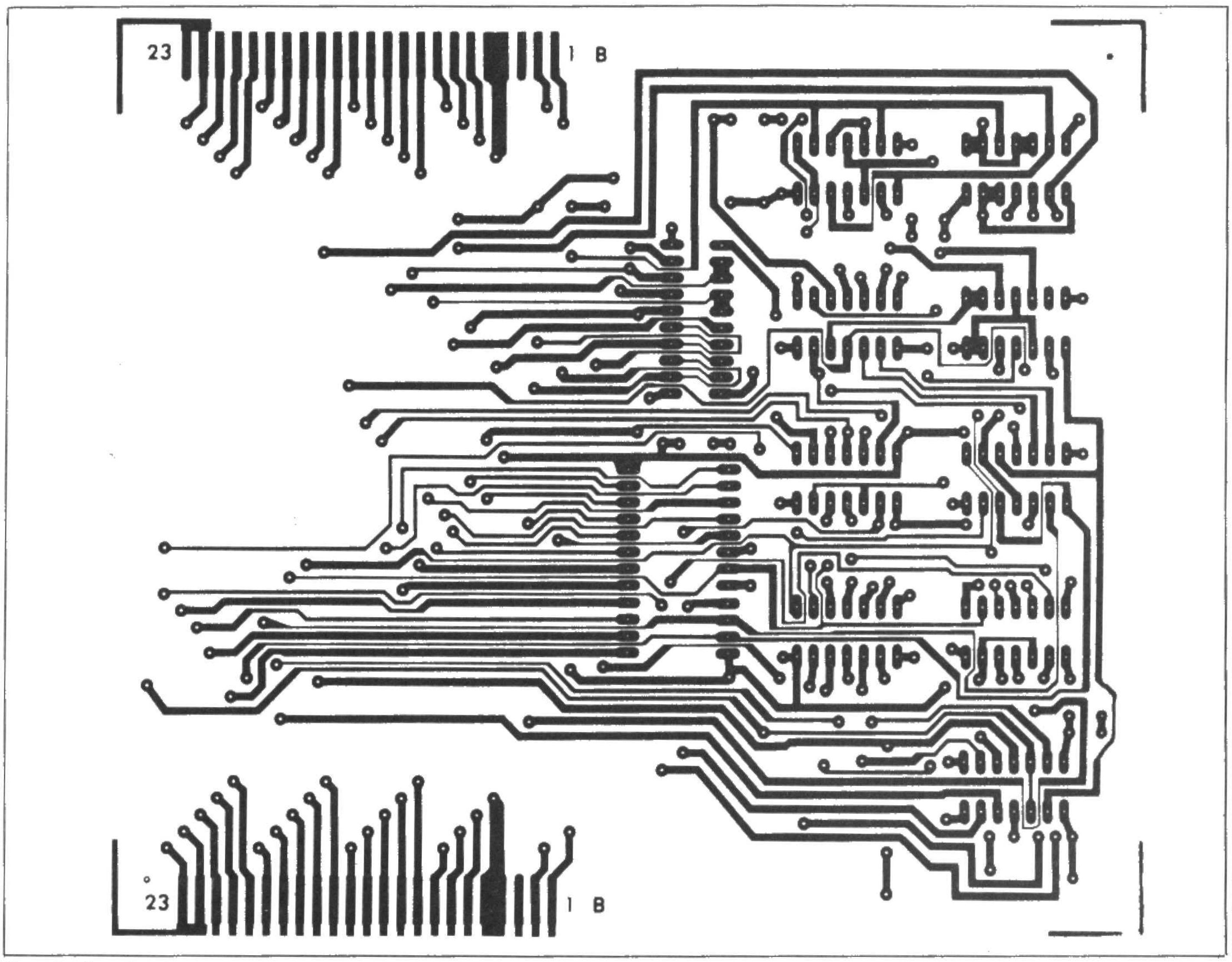
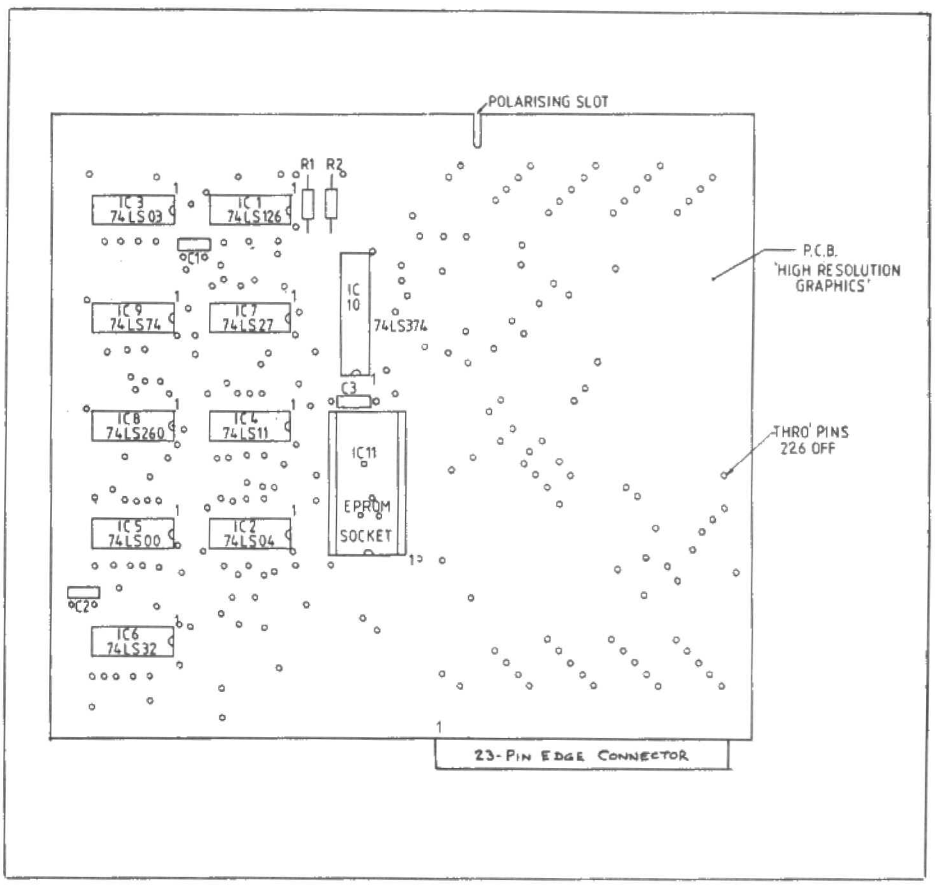


Figure 2. Artwork and Legend

track surfaces, as any mistakes introduced can be extremely difficult to find afterwards! Insert R1, R2 and C1 to C3. Fit the 24 pin dil Skt. (IC11) and mount all IC's. Solder each component lead, remove excess wire etc. and fit Eprom IC 11.

Two edge connectors are apparent on the PCB. One end has a slot cut in position three; the ram pack fits here. The other end requires a 2 x 23 way socket to be fitted which will insert into the ZX81 expansion port (or printer/ keyboard adaptor). Pins A3 and B3 are not used as the socket has a locating peg fitted in this position. Slot the socket terminals over the pads, and solder each. one — they may need bending down to the board first! Clean both track faces with a suitable solvent and stiff brush, then closely inspect all joints. Special attention to detail may prevent damage to both module and ZX81 from occuring.



Testing and Using the Module

Connect module, ZX81 and RAM pack as shown in FIG. 3. If you wish to use a printer or external keyboard, connect these to the computer first, then fit the graphics module and RAM pack.

Connect up the computer and switch on. After several seconds, the [K] cursor will appear as normal (the actual time taken is dependant on the size of RAM used) if not, switch off and remove the module. Try running the computer and RAM pack only to make sure it still functions, then check the module for construction faults. One common fault when using PCB track pins, lies with not pushing them far enough through the board, but still applying solder, thereby hiding the fault. Other points to check are IC orientation and correct values in appropriate positions. Type SLOW 2 NEWLINE and if all is well, the statement Ø/GØØ7 will appear in the bottom left corner. Now type CLS 3 NEWLINE and the HI-RES screen will appear inverted in black with a white border. Of course, single key commands should be used — not individual letters! Type CLS 3 NEWLINE again and the HI-RES screen will revert to white. Type in a simple program line e.g. 1Ø REM NEWLINE. The [K] cursor appears but not the program, this is because SLOW 2 is a HI-RES mode command and program lines are not displayed in this mode. Now type SLOW NEWLINE and NEWLINE again. The screen is now back to LO-RES mode and line 1Ø will be displayed followed by GØØ7 which is the start of HI-RES display area. By now, you can feel reasonably confident that the module is working, so type in PROGRAM 1 just to get an idea of what to expect.

PROGRAM 1

```
1Ø   CLS 2
2Ø   SLOW 3
3Ø   For I = Ø to 255
4Ø   PLOT 12, I, 191
5Ø   PLOT 3, 255—I, 191
6Ø   NEXT I
7Ø   For I = Ø to 191
8Ø   PLOT 12, Ø, I
9Ø   PLOT 3, 255, 191 — I
1ØØ  NEXT I
11Ø  CLS 3
12Ø  GOTO 3Ø
RUN NEWLINE
```

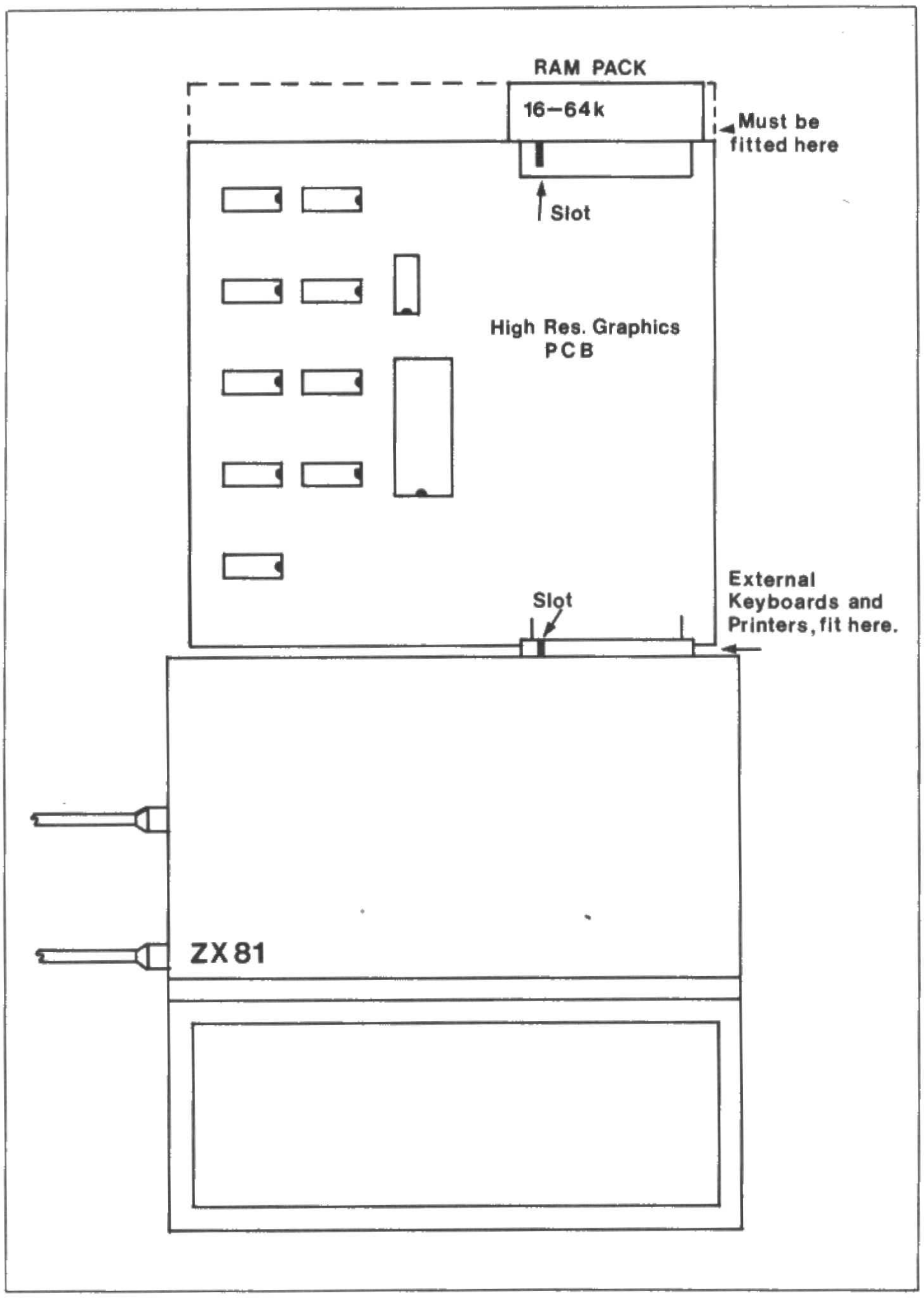


Figure 3. Connecting to ZX81

SUMMARY OF BASIC STATEMENTS

STATEMENT	OPERATION
SLOW or SLOW Ø	SETS LO-RES MODE
SLOW 1 to 6	SETS HI-RES MODE AND PRINT MODE AS FOLLOWS:-
SLOW 1	PRINT CHR$, REVERSED VIDEO
SLOW 2	PRINT NORMAL
SLOW 3	PRINT AT PLOT POSITION, TEXT FOREGROUND, WHITE
SLOW 4	PRINT AT PLOT POSITION, TEXT FOREGROUND BLACK
SLOW 5	PRINT AT PLOT POSITION, TEXT BACKGROUND INVERTED
SLOW 6	PRINT AT PLOT POSITION, TEXT FOREGROUND INVERTED
CLS OR CLSØ	CLEARS LO-RES DISPLAY
CLS 1	CLEARS HI-RES DISPLAY WITH BLACK
CLS 2	CLEARS HI-RES DISPLAY WITH WHITE
CLS 3	INVERTS HI-RES DISPLAY
CLS1 and 2 also reset PLOT position and graphics origin to bottom left side of the screen.	
COPY OR COPY Ø	COPIES LO-RES DISPLAY TO PRINTER
COPY 1	COPIES HI-RES DISPLAY TO PRINTER
PLOT — 1, X, Y	SAME EFFECT AS ORIGINAL PLOT X, Y
PLOT Ø, X, Y	SAME EFFECT AS ORIGINAL UNPLOT X, Y
PLOT 13Ø, X, Y	REPOSITIONS THE GRAPHICS ORIGIN
PLOT n, X, Y	HAS THE FOLLOWING EFFECTS FOR THE DIFFERENT VALUES OF n:-
n = 1	DRAWS A LINE TO ABSOLUTE CO-ORDINATES IN WHITE
n = 2	DRAWS A LINE TO ABSOLUTE CO-ORDINATES IN BLACK
n = 3	DRAWS A LINE TO ABSOLUTE CO-ORDINATES INVERTED
n = 4	AS 3, BUT MISSING LAST POINT ON LINE
n = 5-8	AS 1 TO 4, BUT RELATIVE COORDINATES
n = 33-4Ø	AS 1 TO 8, BUT WITH A COARSE DOTTED LINE
n = 65-72	AS 1 TO 8, BUT WITH A FINE DOTTED LINE
n = 97-1Ø4	AS 1 TO 8, BUT WITH A CHAIN DOTTED LINE
n = 9-16	AS 1 TO 8, BUT PLOTS A SINGLE PIXEL
PLOT 12 and PLOT 16 miss out the Pixel and simply move the PLOT position.	
n = 41-48	AS 1 TO 8, BUT DRAWS AND FILLS A TRIANGLE BETWEEN CURRENT AND PREVIOUS TWO PLOT POSITIONS
n = 73-8Ø	AS 41 TO 48, BUT THE TRIANGLE IS TEXTURED, EXCEPT IN INVERT MODES

Program 1 produces a MOIRE PATTERN in both normal and inverted HI-RES MODES and is continual. Use BREAK to stop the program running.

The texture is defined by bytes 897Ø and 8971. Useful values to POKE here are Ø, 1, 17 and 85. If 16 is added to the above values for n, the "previous" PLOT position is unchanged once the PLOT statement is completed.

The 'READ POINT' byte at 8983 contains a non-zero number after a PLOT 12 statement, if the pixel is black.

Graphics Routines

5 routines can be called from machine code and the entry points are as follows:-

1. DELETE DISPLAY FILE.
   CALL ADDRESS 11737.
   Temporarily sets FAST mode and should be followed by CALL 519.
2. CHECK AND SET UP DISPLAY FILE.
   CALL ADDRESS 118Ø7.
   Checks if a HI-RES display exists and sets up a new one if necessary. Also checks if system variables have been initialised.
3. CLEAR THE SCREEN.
   CALL ADDRESS 11858.
   Equivalent to CLS n in Basic and should be entered with REG A containing the required value of n.
4. PLOT ROUTINES
   CALL ADDRESS 1Ø566.
   ALL PLOT statement facilities are available by calling this routine. On entry, REG A must hold the appropriate PLOT number and REG's BC and DE must hold the X and Y coordinates respectively. These co-ordinates are signed 16 BIT numbers.
5. SETTING HI/LO RES MODE.
   Display modes can be switched by changing the value held in the Z80 — I REG. Values of 3Ø and 31 in I set LO and HI-RES modes respectively.

An area of memory between addresses 8448 and 87Ø3 is reserved for USER DEFINED CHARACTER definitions, but could be used for storing machine code etc. This area is protected from NEW. Also, 100 bytes of RAM are free from 9Ø18 to 9117 which are safe from NEW, but will be cleared upon initialisation of the system variables. POKEing addresses outside of these ranges may cause a crash and is not recommended.

Point Plotting.
Plot n, X, Y

The parameter n used in this statement behaves differently to the original PLOT and lies in the range — 1 to 130. Co-ordinates X and Y specify a position on the screen, which may be either absolute or relative. With absolute co-ordinates, the new PLOT position is given as X pixels to the right and Y pixels up from the Graphics origin, whereas with relative co-ordinates, the new PLOT position is given as X pixels right and Y pixels up from the previous PLOT position. The HI-RES screen has 256 pixels across and 192 pixels high with graphics origin located at the bottom left hand corner. Hence points on the screen have an X co-ordinate in the range Ø to 255 and Y co-ordinate in the range Ø to 191.

Drawing Lines

Lines are drawn from the previous PLOT position to the current PLOT position. If the current position is off the screen, it is interesting to note that lines will still be drawn to the edge of the display area. Various types of solid, dotted or dashed lines can be drawn as listed in the Basic statements. Also, note that broken line types can be obtained by adding 32, 64 or 96 to values of n that give solid lines.

Filling Triangles

Statements that will draw and fill in triangles are similar to those for drawing lines. Vertices of the triangle consist of the current PLOT position and the previous two PLOT positions. The triangle will only be filled if it lies completely within the screen. If any of the vertices lie off the screen, then error B will result. In invert mode, a triangle can be plotted, missing out the last edge or the edge between current and previous PLOT positions. This enables adjacent triangles to join up properly. Textured triangle fill is available for shading, cross-hatching etc. and is user definable. Two bytes 897Ø and 8971 are rotated, respectively, by 1 and 3 bits to the right for each new row of the triangle. They are then ORed together, and the resultant pattern used to fill that row of the triangle.

PATTERN	897Ø	8971
Grey	85	Ø
Left Diagonal Shading	Ø	17
Right Diagonal Shading	17	Ø
Right Diagonal Shading (Coarse)	1	Ø
Cross Hatching	17	17
Fine Dots	Ø	1

Line Types

Four standard line types are determined by bytes 9012 — 9015 respectively. They can be re-defined by POKEing, the line pattern being an inverse of the bit pattern.

Read Point

The state of any pixel, on the screen, is determined by moving the PLOT position to that pixel; (USE PLOT 12) and then PEEK 8983. If number = Ø the pixel is white, otherwise a single bit of the number will be set, and the pixel black.

HI-RES Printing

The module provides six different modes of operation for the PRINT statement. A "PRINT mode set" number is given by the value of parameter n in the statement SLOW n or FAST n, used to set HI-RES mode. Text can be printed right down to the bottom of a HI-RES screen in all PRINT modes, but only as string results. If numeric results need to be printed, they should be converted to strings by preceeding with STR$. (Note that SCROLL is inoperative in HI-RES mode). PRINT modes 1 and 2 are as for LO-RES, except mode 1 which is inverted. PRINT modes 3-6 are tied to the PLOT position which MOVES as characters are printed. Characters begin printing at the top left corner of the screen. A semi-colon, if used, holds the PLOT position at the end of the last character printed, otherwise the PLOT position goes to the start of a new line. As PRINT AT and TAB do not work, the PRINT statement is usually preceeded by a statement to move the current PLOT position (eg. PLOT 12 or PLOT 16).

User Defined Graphics

A section of the character set can be re-defined as required and PROGRAM 2 enables this to be done. CHR$ 160 to 191 (inverse 4 to Z) are used for this purpose, allowing 32 characters to be stored in 256 bytes of RAM, starting at address 8448 and protected from NEW. Each character definition consists of 8 bytes corresponding to 8 rows of pixels in the CHR. 8 pixels in each row correspond to the 8 bits of each byte, with left most significance. To redefine a character, the 8 binary numbers for each row must be worked out as shown in Fig 4 and each number should then be POKEd into 8 consecutive memory locations of the first CHR table. The first address for the table will be 8448 + 8 ⋆ (character code — 16Ø) the character code being a number between 16Ø and 191. Memory locations outside of 8448 to 8703 must not be POKEd.

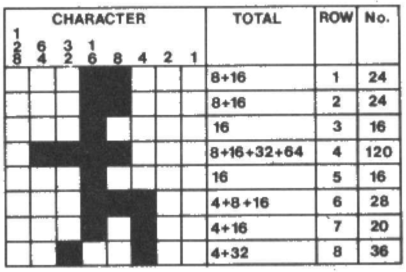


Figure 4. Re-defining CHR$

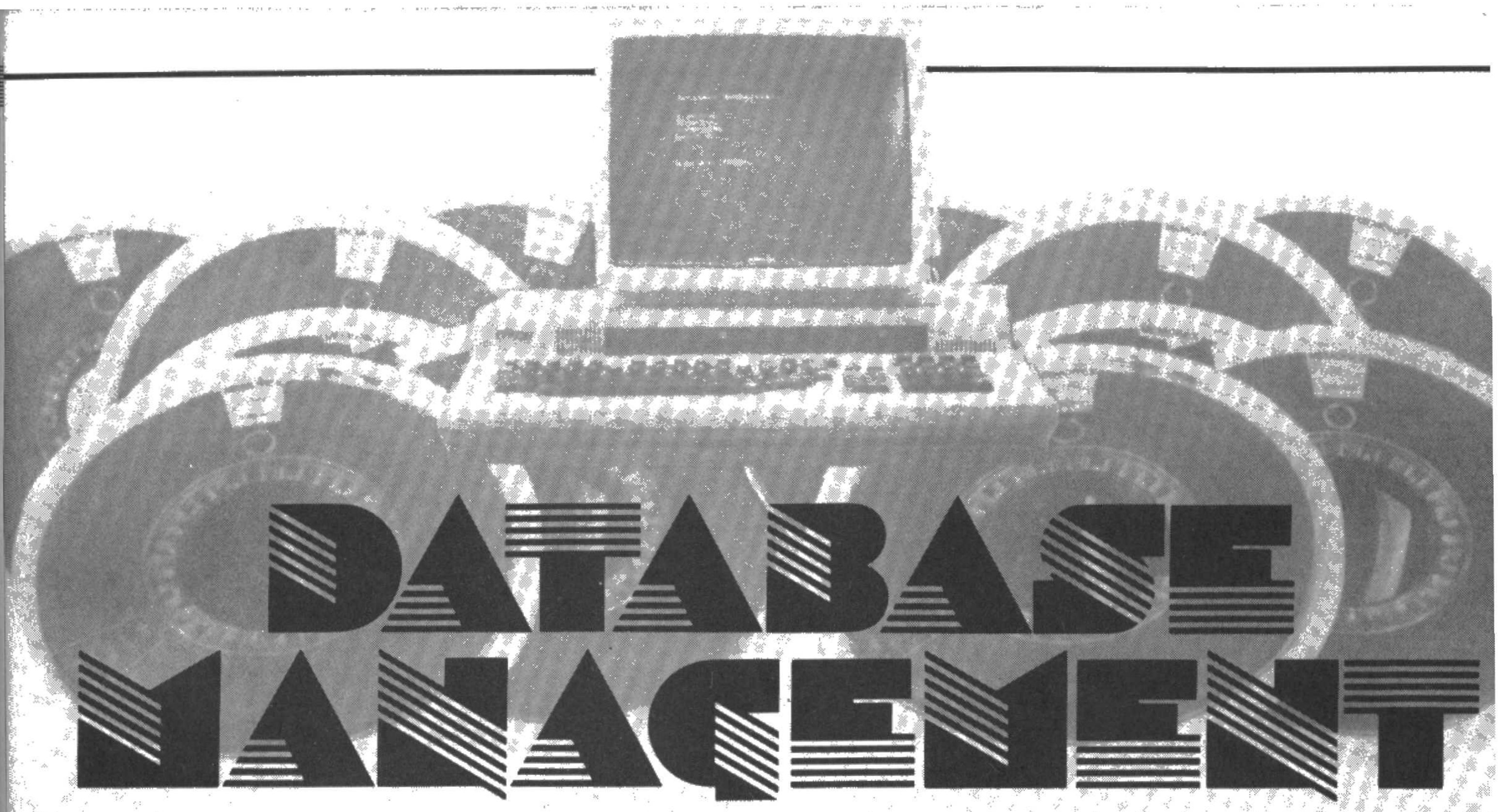
If CHR$ 16Ø is to be re-defined, then from above formula; address = 8448 + 8 ⋆ (16Ø), or 8448:

PROGRAM 2

```
1Ø   SLOW
2Ø   LET C = 16Ø
3Ø   FOR I = Ø TO 7
4Ø   PRINT AT Ø, Ø; "GIVE ROW"; I + 1
5Ø   INPUT N
6Ø   POKE (8448 + 8 ⋆ (C — 16Ø) + I), N
7Ø   NEXT I
8Ø   CLS 2
9Ø   SLOW 2
1ØØ  PRINT CHR$ 16Ø
```

The program prompts for lines 1 to 8 so enter each number associated with that row from FIG 4. If other characters (161 to 191) are to be re-defined then LINE 2Ø and LINE 1ØØ should be changed accordingly. Note that inverse CHR$ 16Ø — 191 will be printed as normal in LO-RES mode, and the re-defined version printed only in HI-RES mode.

Continued on page 53



DATABASE MANAGEMENT

Part 1

by N. L. J. Fawcett

Sooner or later most home micro owners find that they need or want to write a program that will enable them to store and retrieve data in such a manner that any record can be found immediately, without the need for lengthy searches through what could be very large files. In addition to this a good program must allow entries to be added and deleted quickly and enable extra space to be made available when an entry expands beyond one record.

This article will cover Linked Lists, Free Lists and Trees. First each structure will be looked at separately and then at the end a fully working example will demonstrate how all these methods can be combined to produce a fast and effective filing program.

All examples are written in Microsoft Basic and assume a disk based system, although there is nothing to prevent these ideas being adapted for use on cassette or RAM based files.

As stated previously, the information presented here is meant to be a basic introduction to data structures and not an in-depth analysis, therefore only relevant theory will be discussed and worked on here.

Linked Lists

This is one of the simplest data structures to use and understand. Its primary use is to indicate an association between two or more items of data. To do this a 'pointer' is included in every record, which 'links' it to another record. If a record has no further links, i.e. it is the end of a chain then its 'link-pointer' is set to zero. Let us take an example; a company may hold customers names and addresses in one file and order records in another file. A pointer is used in the name and address file to indicate which record in the order file was the most recent transaction for that customer. From here the linked list is used to point, in turn, to each previous order until his original (first ever) transaction is reached.

Figure 1 illustrates this.

If customer B is next to make a purchase then record 12 is used to store the details, as it is the next available record. The 'link-pointer' of record 12 is set to the current contents of the 'pointer' in the name and address record i.e. 8. The pointer from the name and address record is now set to the new record i.e. 12. This procedure can be continued *ad infinitum* for all possible customers and their purchases, within the realms of storage space available to support both files.

So it can be seen that, as well as allocating space in each record for the data, provision must also be made to store the 'link-pointer'. This is normally achieved by including a two-byte field in each record, and converting the 'link-pointer' from an integer to a string. (MKI$ in Microsoft Basic). If your version of Basic does not support this, or an equivalent function, then use the following

(i)		(ii)		(iii)		(iv)	
Dummy	2	Dummy	3	Dummy	4	Dummy	5
Empty	3	Data	-1	Data	-1	Data	-1
Empty	4	Empty	4	Data	-1	Data	-1
Empty	5	Empty	5	Empty	5	Data	-1
Empty	0	Empty	0	Empty	0	Empty	0

(v)		(vi)		(vii)		(viii)	
Dummy	0	Dummy	3	Dummy	5	Dummy	2
Data	-1	Data	-1	Data	-1	Empty	5
Data	-1	Empty	0	Empty	0	Empty	0
Data	-1	Data	-1	Data	-1	Data	-1
Data	-1	Data	-1	Empty	3	Empty	3

Figure 2. Principles of a free list.

Customer A	11	Customer B	8	Customer C	10

Data	9	Data	5	Data	6	Data	7	Data	4	Data	1	Data	3	Data	2	Data	0	Data	0	Data	0
11		10		9		8		7		6		5		4		3		2		1	

Figure 1. Principles of a linked list.

routine, where X represents the 'link-pointer' and X$ represents the converted string:-

X$=CHR$ (X-256*INT (X/256))+CHR$ (INT (X/256))

NB: X$ may now contain control characters which might affect the way in which your computer handles disk I/O, so please consult your manual first,

There are many other ways in which the linked list can be used and other forms in which it can be provided, but for our purposes the above explanation will suffice.

Free Lists

A free list performs the function of ensuring that when a new record is required, the next available, empty record is allocated for use — and at the same time making sure that deleted records are added to the list of empty records.

Once again a two-byte field is required in each record, which represents either the address of the next free record or that the record is in use. A static two-byte field is also required, somewhere, to store the current next-free-record-pointer. When this static two-byte field contains a zero then the file is full. In Worked example the first record will be a dummy record and act as the static pointer. With reference to Figure 2, it can be seen that at creation time (Diagram i), the file contains one static (dummy) record, with the address of the first free record, and four free records, each with the address of the next free record, except for the last one, which contains a zero, signifying, no further records. Each time data is written into a record, the program must first check that the file is not full (pointer=0 as in Diagram v). Assuming it is not, the program then uses the record addressed by the dummy record. The contents of the two-byte field in the record used, are then copied into the dummy record and replaced by a -1, to declare the record in use. (Diagrams ii to v).

To make a deletion, the contents of the two-byte field in the dummy record are copied into the two-byte field of the record being deleted. The address of the deleted record is then written into the dummy record, (Diagrams vi to vii). It can now be seen that deleted records will be re-allocated in reverse order of that in which they were deleted — thus ensuring that all free records are used and not left dormant.

Trees

The tree file is a powerful and complex data structure, which comes in many shapes and sizes, for many varied applications. Often called a binary tree, (a true binary tree has a unique structure differing from that described here), this file is graphically represented like a family tree. The components of the structure have been given descriptive names, most of which have been purloined directly from their botanical cousin, the real tree. Data records are called Nodes, starting with a Root Node, and terminating in Leaf Nodes. Links between Nodes are called Branches. A Node which branches forward to a new Node is a Parent Node, whilst the Node branched to is a Sibling. The theory of operation is this: Data to be added to the file is first compared with the Root Node. If its ASCII value is less than that of the Root Node then you branch left — if greater then branch right. If the new Node is free then the data is stored here, otherwise another comparison is made, again branching accordingly, until a free record is reached, see Figure 3.

Each Node represents a record in the file. In this example, sixteen bytes have been reserved in each record to manage the file.

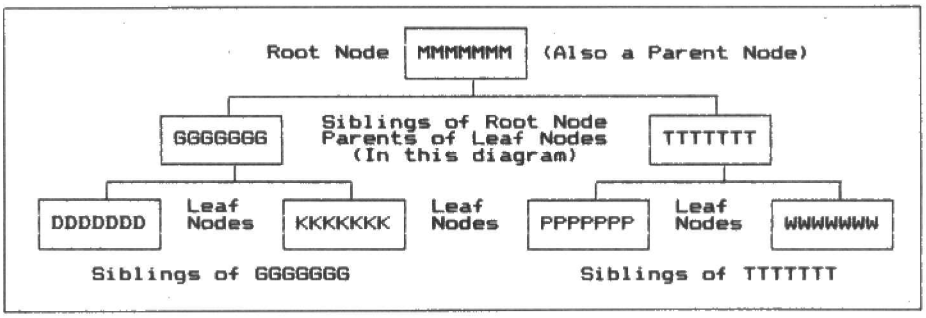


Figure 3. Formation of a tree.

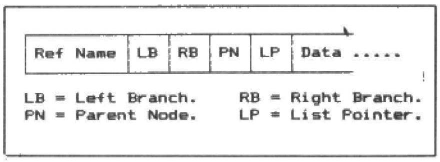


Figure 4. Layout of a mode.

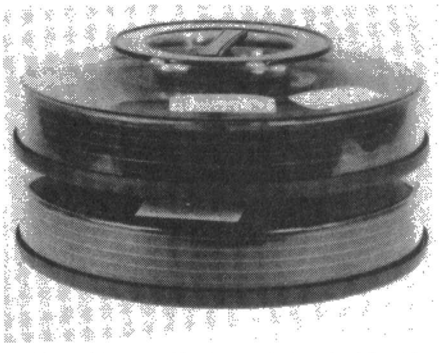
MMMMMMM	4	2	0	8	Data ...
TTTTTTT	3	5	1	-1	Data ...
PPPPPPP	0	0	2	-1	Data ...
GGGGGGG	7	6	1	-1	Data ...
WWWWWWW	0	0	2	-1	Data ...
KKKKKKK	0	0	4	-1	Data ...
DDDDDDD	0	0	4	-1	Data ...
	0	0	0	9	
	0	0	0	10	
	0	0	0	11	
	0	0	0	12	
	0	0	0	0	

Figure 5. Tree Representation

The layout of these bytes is shown in Figure 4.

The Ref Name is the portion of the data that is used in the comparison, and is therefore the primary data — stock code, part number etc. A disadvantage of this structure is not being able to have more than one occurrence of the Ref Name. This can cause problems if the file is to be used for names and addresses. The best way to overcome this limitation is to create a formula, enabling unique Ref Names to be extracted from the name and address, i.e. 1st 3 letters of surname + 1st 3 letters of postal town or district + initials. (Altering the program to allow duplicate Ref Names, is not advised as it causes serious fragmentation, and results in slow access time).

The Left and Right Branch pointers hold the address of the next record if there is one, or a zero if there is not.



The Parent Node pointer holds the address of the Parent Node for a given Sibling, and is used mostly when deleting a record or traversing the tree.

The List Pointer is used in the same way as discussed above, under Free Lists. It also doubles up as the Linked List pointer when adding extra records from another file if required.

The rest of the record is dedicated to storing the actual data. If the primary data being stored is a stock code, or some other unique code, then there is obviously no need to store the same information twice — the Ref Name field becomes the primary data field. Likewise, there is no limitation on the size allocated for the Ref Name, although 8 characters is advised as both the minimum, and, perhaps, the optimum length.

The structure will work at its best if; a) the Root Node is balanced to the centre of the ASCII range — so we will artificially set it to all M's, and b) the data is as random as possible — if data was entered in alphabetical order, the file would become lop-sided. A perfect tree would only require sixteen comparisons to search a 65,536 record file! This is illustrated in Figure 5.

A very useful by-product of the tree file, is that, technically, the data is stored in alphabetical order, and, thereby, requires no complicated sort program, to produce a sorted list. A program to 'traverse' the tree and thus generate a sorted list will be given in the next issue, under part two.

The included program utilises all the forementioned theory to provide an excellent filing system, that should easily be adapted for most types of micro on the market.

```
( Program to create the file. )

10      CLS
100     OPEN "R",£1,"B:DBASE.DAT",128
110     FIELD £1, 8 AS REF$, 2 AS LB$, 2 AS RB$, 2 AS PN$, 2 AS LP$,
        25 AS NME$, 25, AS ROAD$, 30 AS TOWN$, 32 AS COUNTY$
900     LSET LB$=MKI$(0) : LSET RB$=MKI$(0) : LSET PN$=MKI$(0)
910     LSET NME$=SPACE$(25) : LSET ROAD$=SPACE$(25)
920     LSET TOWN$=SPACE$(30) : LSET COUNTY$=SPACE$(32)
1000    LSET REF$="MMMMMMMM" : LSET LP$=MKI$(2)
1010    PUT £1,1
1020    LSET REF$=SPACE$(8)
1100    FOR I%=2 TO 255
1110    LSET LP$=MKI$(I%+1) : PUT £1,I%
1120    NEXT I%
1200    LSET LP$=MKI$(0) : PUT £1,256
20000   CLOSE '
32767   END
```

Listing 2. Program to Create the file.

```
1Ø      CLS
1ØØ     OPEN "R",£1,"B:DBASE.DAT",128
11Ø     FIELD £1, 8 AS REF$, 2 AS LB$, 2 AS RB$, 2 AS PN$, 2 AS LP$,
        25 AS NME$, 25 AS ROAD$, 3Ø AS TOWN$, 32 AS COUNTY$
2ØØ     PRINT TAB(2Ø); "Name & Address file card system."
21Ø     FOR I%=1 TO 4 : PRINT : NEXT I%
22Ø     PRINT TAB(2Ø);"Add a new record ........ ( 1 )"
23Ø     PRINT TAB(2Ø);"Interrogate a record .... ( 2 )"
24Ø     PRINT TAB(2Ø);"Return to BASIC ......... ( 3 )"
3ØØ     FOR I%=1 TO 3 : PRINT : NEXT I%
31Ø     PRINT TAB(21);"Please enter option 1-3  ";
32Ø     INPUT OPTN% : IF OPTN%<1 OR OPTN% >3 THEN 31Ø
33Ø     ON OPTN% GOSUB 1ØØØ,2ØØØ,2ØØØØ
34Ø     CLS : GOTO 2ØØ
1ØØØ    CLS
1Ø1Ø    INPUT "Enter REF NAME... "; RN$ : IF RN$="END" THEN RETURN
1Ø2Ø    RN$=LEFT$(RN$+SPACE$(8),8)
1Ø3Ø    GOSUB 13ØØØ
1Ø4Ø    IF MATCH% THEN PRINT "* Already on file *" : GOTO 1Ø1Ø
1Ø5Ø    IF RN$>REF$ THEN LSET RB$=MKI$(NX%) ELSE LSET LB$=MKI$(NX%)
1Ø6Ø    PUT £1,P% : GET £1,NX% : NX1%=CVI(LP$)
1Ø7Ø    LSET REF$=RN$ : LSET PN$=MKI$(P%)
1Ø8Ø    LSET LP$=MKI$(-1) : GOSUB 15ØØ : PUT £1,NX%
1Ø9Ø    GET £1,1 : LSET LP$=MKI$(NX1%) : PUT £1,1
11ØØ    GOTO 1ØØØ
15ØØ    PRINT
151Ø    INPUT "Enter Name ....... "; N$
152Ø    INPUT "Enter Address 1 .. "; A$
153Ø    INPUT "Enter Town ....... "; T$
154Ø    INPUT "Enter County/Pcode "; C$
155Ø    LSET NME$=N$ : LSET ROAD$=A$ : LSET TOWN$=T$ : LSET COUNTY$=C$
156Ø    RETURN
2ØØØ    CLS
2Ø1Ø    INPUT "Enter REF NAME... "; RN$ : IF RN$="END" THEN RETURN
2Ø2Ø    RN$=LEFT$(RN$+SPACE$(8),8)
2Ø3Ø    GOSUB 13ØØØ
2Ø4Ø    IF MATCH% THEN 2Ø5Ø ELSE 25ØØ
2Ø5Ø    CLS : FOR I%=1 TO 5 : PRINT : NEXT I%
2Ø6Ø    PRINT RN$ : PRINT NME$ : PRINT ROAD$ : PRINT TOWN$ : PRINT COUNTY$
2Ø7Ø    FOR I%=1 TO 5 : PRINT : NEXT I%
2Ø8Ø    INPUT "Carriage return to continue... "; DUMMY$
2Ø9Ø    RETURN
25ØØ    CLS : PRINT "***** Not on File. *****" : PRINT
251Ø    GOTO 2Ø1Ø
13ØØØ   GET £1,1 : NX%=CVI(LP$) : P%=1
13Ø1Ø   IF RN$=REF$ THEN MATCH%=-1 : RETURN
13Ø2Ø   IF RN$>REF$ THEN REX%=CVI(RB$) ELSE REX%=CVI(LB$)
13Ø3Ø   IF REX%=Ø THEN MATCH%=Ø : RETURN
13Ø4Ø   GET £1,REX% : P%=REX% : GOTO 13Ø1Ø
2ØØØØ   CLOSE
32767   END
```

Listing 1. The File Program

Hi-Res Graphics *Continued from page 50*

SAVEing HI-RES Pictures

Normally, the HI-RES display file is deleted automatically by the SAVE command. However a direct call to the save routine — RAND USR 764 — in FAST mode allows the HI-RES display to be saved with a name, or empty string (SAVE " "). Before loading, ensure the display is set or type CLS 2 otherwise it will be deleted by the first HI-RES statement in the program.

Finally, the command POKE 8833, Ø (or 237) will correct a display that bends at the top of a picture, and should be done after a HI-RES display file is set up. Following, are three programs showing circle plotting and three-dimensional effects and are worth entering.

PROGRAM 3 "CIRCLES"

```
1Ø   LET D = Ø.Ø99
2Ø   LET X = 9Ø
3Ø   LET Y = Ø
4Ø   CLS 2
5Ø   SLOW 4
6Ø   PLOT 13Ø, 127, 95
7Ø   PLOT 12, X, Y
8Ø   FOR I = Ø TO 63
9Ø   LET X = X + D * Y
1ØØ  LET Y = Y — D * X
11Ø  PLOT 2, X, Y + X * D/2
12Ø  NEXT I
13Ø  PLOT 9, 127, 95
14Ø  LET X = X — 1Ø
15Ø  CLS 3
16Ø  GOTO 7Ø
RUN NEWLINE
```

PROGRAM 4 "CONTOURS"

```
1Ø   CLS 2
2Ø   SLOW 2
3Ø   PLOT 13Ø, 127, 1Ø
4Ø   FOR P = Ø TO 12
5Ø   LET X 1 = P * 1Ø
6Ø   LET Y 1 = P * 7
7Ø   FOR Q = Ø TO 12
8Ø   LET Z =—2Ø * SIN (P/2) * SIN(Q/2)
9Ø   LET X2 = (P-Q) * 1Ø
1ØØ  LET Y2 = Z + (P+Q) * 7
11Ø  PLOT 12, — X1, Y1
12Ø  PLOT 2, — X2, Y2
13Ø  PLOT 12, X1, Y1
14Ø  PLOT 2, X2, Y2
15Ø  LET X1 = X2
16Ø  LET Y1 = Y2
17Ø  NEXT Q
18Ø  NEXT P
19Ø  CLS 3
RUN NEWLINE
```

PROGRAM 5

```
1Ø   CLS 1
2Ø   FAST 2
3Ø   PLOT 13Ø, 127, 1ØØ
4Ø   FOR X = 1 TO 12Ø STEP 2
5Ø   LET U = X * X
6Ø   LET L = INT (Ø.5 + SQR (144ØØ —U)/4)
7Ø   LET M = — 1ØØ
8Ø   FOR Y = — L TO L
9Ø   LET R = (U + Y * Y * 16) / 1ØØØ
1ØØ  LET Z = 2.5 * Y — 15Ø / R * SIN R
11Ø  IF Z<M THEN GOTO 15Ø
12Ø  LET M = Z
13Ø  PLOT 9, X, Z
14Ø  PLOT 9, — X, Z
15Ø  NEXT Y
16Ø  NEXT X
RUN NEWLINE
```

This program takes about four minutes to run, but the result is quite spectacular.

PARTS LIST FOR ZX81 HI-RES GRAPHICS

Resistors — All 0.4W 1% metal film

R1,2	1k0	2 off	(M1K0)

Capacitors

C1-3	10nF disc	3 off	(BX00A)

Semiconductors

IC1	74LS 126	(YF50E)
IC2	74LS04	(YF04E)
IC3	74LS03	(YF03D)
IC4	74LS11	(YF09K)
IC5	74LS00	(YF00A)
IC6	74LS32	(YF21X)
IC7	74LS27	(YF18U)
IC8	74LS260	(QY59P)
IC9	74LS74	(YF31J)
IC10	74LS374	(YH16S)
IC11	2716(M8)	(QY58N)

Miscellaneous

P.C. Board		(GB43W)
Track pin	5 pkts	(FL82D)
Socket 24 Pin DIL		(BL20W)
Socket 2x23 way		(RK35Q)
P.C. Edgecon		

A Kit containing all the parts listed above is available.
Order As LK23A Price £28.50

5 BOB'S WORTH

5 Fun Projects From Robert Penfold

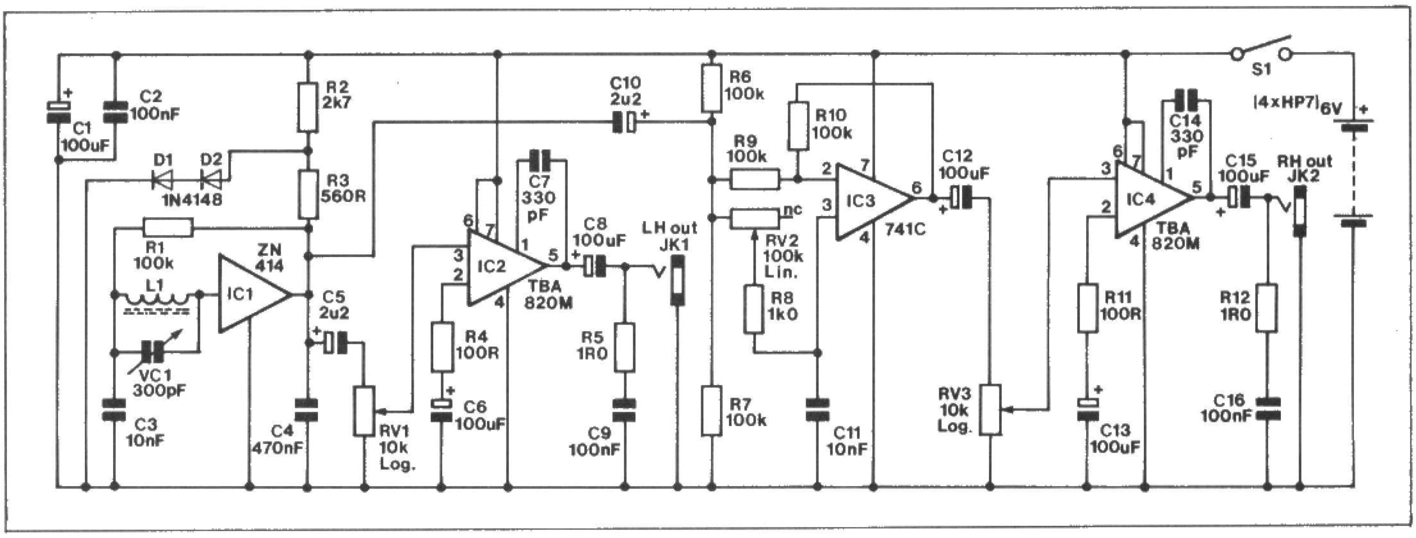


Figure 1. Pseudo stereo AM radio block diagram.

PSEUDO STEREO AM RADIO

This simple radio receiver has been designed to drive a pair of medium impedance (personal stereo type) headphones, but it also gives quite good results when used with low or high impedance loudspeaker if a conventional portable radio is all that is required. Although several AM stereo radio systems are in existence, none of these are currently in use in the U.K., and a simple phase shifting system is used in this circuit to give a pseudo stereo effect.

The R.F., detector, and A.G.C. sections of the circuit are based on the ZN414 used in the standard configuration. L1 can be the tuned winding of any normal MW ferrite aerial, such as a Denco MW5FR. This type of aerial coil invariably seems to have a small coupling winding which is not needed in this application, and it is either removed or just ignored. Some of the audio output from IC1 is coupled by C5 to volume control RV1, and then to the input of an audio power amplifier which is based on IC2. The use of a power amplifier may seem to be unnecessary, but medium impedance (about 35 ohms) headphones require a higher drive current than could be provided by an operational amplifier or similar stage. The TBA820M can readily provide the required voltage gain of about 35dB and has a low quiescent current consumption of only about 4 milliamps which helps to give good battery life.

If mono reproduction is required the phones can be fed from the output of IC2 using series connection for low or medium impedance types, or parallel connection for high impedance headphones. A high impedance (about 64 ohms) loudspeaker can also be driven from IC2. If the pseudo stereo effect is required the phase shifter built around IC3 and the extra audio output stage which uses IC4 must be included. The two most common methods of producing a quasi stereo effect from a mono signal are to introduce anomalies in the frequency response or phasing of the two audio outputs. In this case one output is just the normal audio signal, and the other is phase shifted through IC3 by an amount which varies from zero at low frequencies to 180 degrees at high frequencies.

With the two signals in-phase a strong central stereo image is produced, but with a significant phase difference between the signals the sounds seem to emanate from the sides of the sound stage. The effect of the phase shifter is to give a strong central image at low frequencies, with a spreading of the image at high frequencies. This does not give a true stereo effect, but does give somewhat more satisfactory and realistic results. RV2 controls the frequency at which a significant phase shift is introduced, and effectively acts as a stereo width control (maximum resistance corresponding to maximum separation).

Volume controls RV1 and RV3 must be separate (i.e. single gang) types so that they can also be used to balance the two channels. The only alignment the finished receiver requires is to fix L1 in a position on the ferrite rod that gives full coverage of the MW band. Note that the unit must not be fitted in a metal case as this would screen the aerial.

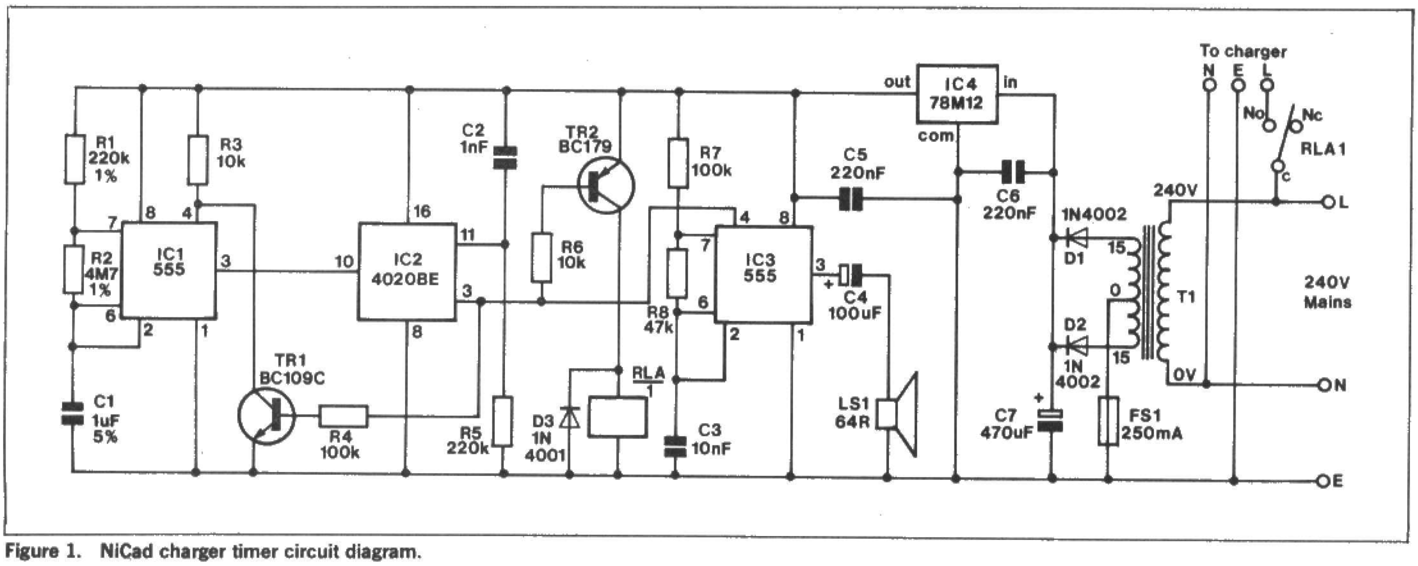


Figure 1. NiCad charger timer circuit diagram.

NICAD CHARGER TIMER

When recharging NiCad cells it is very easy to forget them so that they are left charging for a considerable length of time. This timer can be used to automatically switch off the charger after the normal 15 hour charging time and it also produces an audio alarm signal which indicates to the user that charging has been completed. The unit is connected in the mains supply to the charger which consequently does not require any modification. The circuit can easily be modified to provide a switch-on of other than 15 hours if desired.

The long timing pulse duration required in this application precludes the use of a simple C-R timer circuit. Instead an oscillator and divider chain are used, and with this type of circuit the pulse length is equal to a certain number of clock oscillator cycles. The clock signal is generated by a standard 555 astable (IC1) and the divider is a CMOS 4020BE 14 stage binary type (IC2). C2 and R5 produce a positive reset pulse at switch-on so that IC2 starts with all outputs low. After 8192 clock cycles the Q14 output at pin 3 goes high, and TR1 plus the relay which forms TR1's collector load are both switched off. A pair of normally open relay contacts then cut off the mains supply to the charger. TR1 is switched on when IC2's Q14 output goes high, and it takes the reset input of IC1 low so that the clock oscillator ceases to operate. Thus, once the charger has been cut off from the mains supply it remains switched off until the unit is used again. The circuit is reset ready for reuse by simply disconnecting it from the mains and reconnecting it again, but in practice it is likely that the unit would only be used occasionally and would be disconnected after each recharge anyway.

A second 555 (IC3) astable driving a high impedance loudspeaker is used to generate the audio alarm signal. The reset terminal of IC3 is normally held low by the Q14 output of IC2 so that oscillation is blocked, but at the end of the timing pulse when IC2's Q14 output goes high the alarm generator is able to function normally.

A conventional 12 volt stabilised power supply is used to power the unit. T1 can be any 15-0-15 volt type or twin 15 volt component having a secondary current rating of 100 milliamps or more. It is unlikely that IC4 will need a heatsink.

A switch-on time of 15 hours (54000 seconds) requires a clock cycle period of about 6.59 seconds, and the specified values for R1, R2 and C1 give a suitable clock cycle time. For other charging times the value of R2 and or C1 can be changed. Any change in the value of either component gives a proportional change in the charge time. When initially testing the unit a component of 1nF value can be used for C1, and the relay should then be energised for about 54 seconds after switch-on.

ADDER/SUBTRACTOR

It can often be helpful to compare the input and output signals of an audio amplifier or other audio circuit using an oscilloscope with the two traces adjusted so that they overlap one another as precisely as possible. However, this will only clearly show up quite large changes in the processed signal. and a better method is to use a differential amplifier which shows the difference between the two signals as a single trace. For example, if the signal is subjected to strong second harmonic distortion by the amplifier (or whatever) the difference signal would show a strong content at double the frequency of the input signals. Some oscilloscopes have a built-in differential facility, but it is quite easy to add a simple external adder/subtracter to an instrument which does not.

The circuit is little more than an operational amplifier summing circuit based on IC1a, and a unity gain

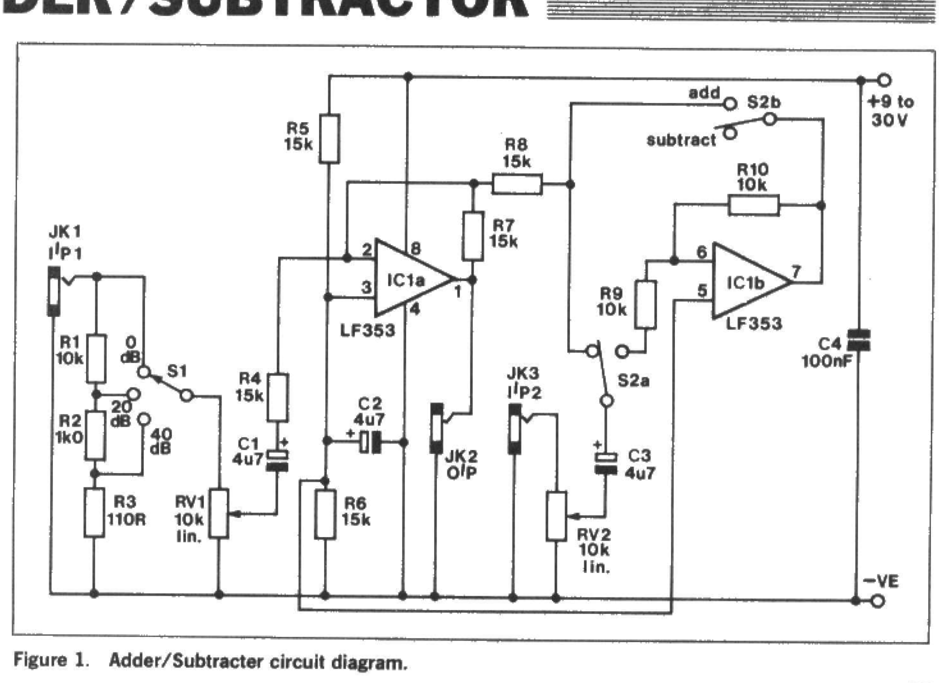


Figure 1. Adder/Subtracter circuit diagram.

inverting amplifier based on IC1b. In the adding mode IC1b is not used, and the two signals are applied to the inputs of IC1a. This mode is used where the processed signal has undergone an inversion, and the two input signals are therefore in antiphase so that the required cancelling effect is produced. RV1 and RV2 are used to balance the two input signals for optimum cancelling, and, if necessary, to prevent the summing circuit from being overloaded. In many cases one input signal will be at a much higher level than the other, and the stronger signal is then applied to input 1 so that the attenuator (S1 plus R1 to R3) can be used to reduce it to a satisfactory level. This makes adjustment of RV1 much easier.

In the subtracting mode IC1b is used to invert one of the signals so that the phasing out of the two signals is still obtained even though they are in-phase. Obviously IC1b introduces a certain amount of phasing and amplitude distortion, but at audio frequencies, provided the circuit is not overloaded, both types of distortion will be too small to be of significance.

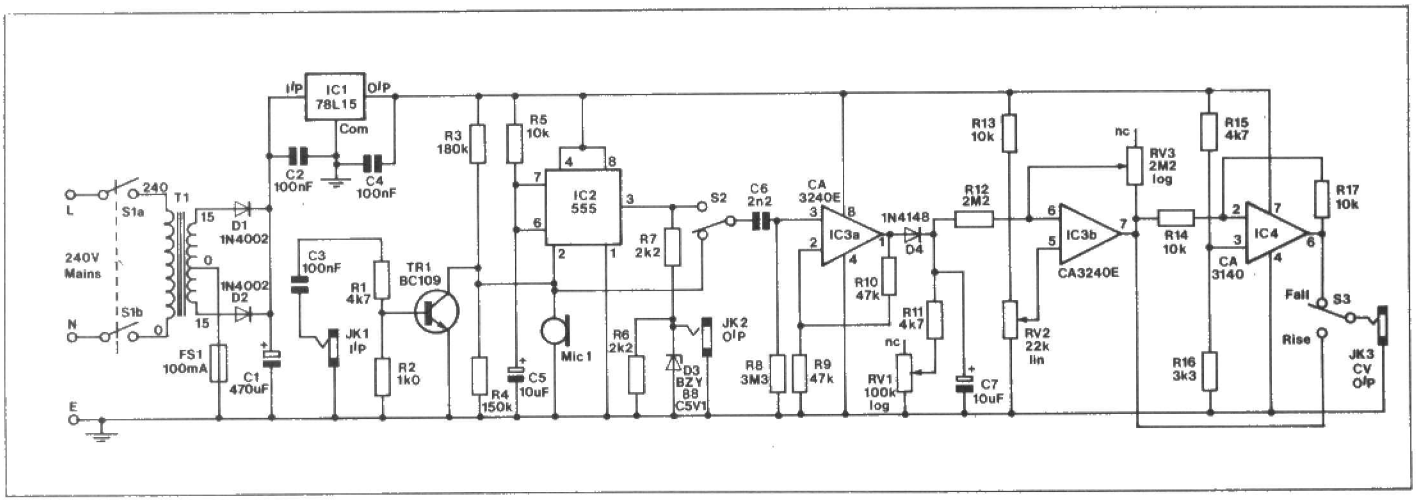


Figure 1. The Syndrum interface unit.

SYNDRUM INTERFACE

This circuit can be used in conjunction with a monophonic synthesiser having gate and CV inputs to effectively form a sophisticated syndrum capable of producing a wide range of interesting effects. The main function of the circuit is to generate a trigger pulse when thepick-up is activated. The latter is a crystal microphone insert or a 27mm piezo transducer which is mounted on a drum, pad of rubber, or whatever. When operated, the first negative output half cycle from the transducer triggers the 555 monostable circuit based on IC2, and this gives a positive 5 volt trigger pulse of about 100ms in duration at JK2 (a nominal 15 volt pulse can be obtained from pin 3 of IC2). This pulse length should be satisfactory, but practically any desired figure can be obtained by altering the value of R5 and/or C5. The circuit can be triggered using a positive trigger pulse of between about 5 and 15 volts applied to JK1, and this permits manual and automatic triggering to be employed together.

With some synthesisers it may be possible to obtain rising and falling pitch syndrum sounds without the use of an external control voltage circuit, but in many cases this would be difficult or impossible. The unit therefore incorporates a rising/falling control voltage generator. IC3a amplifies the trigger signal to produce a strong positive output pulse that charges C7 to a potential of several volts. The exact charge potential depends on how hard the transducer is struck, and the unit is to a degree touch-sensitive in this respect. However, if S2 is set to the other position IC3a is fed with the output of IC2 and C7 then charges to about 10 volts or so each time the unit is operated. D3 prevents C7 from discharging into the output stage of IC3a, and the decay time of the voltage is therefore largely controlled by RV1. IC3b is a level shifter and inverting amplifier, but it really acts as an attenuator since its voltage gain is never more than unity. RV2 acts as the pitch control while RV3 is used to control the sweep width. IC4 is a straight forward unity gain inverter, and this enables a rising or falling voltage (pitch) to be selected using S3.

The circuit is powered from a simple 15 volt stabilised mains power supply unit which can comfortably provide the supply current of only about 20 to 25 milliamps.

MICROPHONE PREAMP/LIMITER

Although this microphone preamplifier and limiter is very simple it provides a useful level of performance. It is primarily intended for use ahead of a mixer and tape deck, but it could, no doubt, be used in other, similar applications. Many tape decks have a built-in limiter, but there is a drawback in using a single limiter with several signal sources in that an overload from one source can effectively reduce the signal level provided by the other sources. Using a separate limiter for each input signal totally eliminates this problem.

The preamplifier is quite straight forward and uses IC1 as a non-inverting amplifier having a voltage gain of about 22 times, and IC2 as an inverting amplifier having a voltage gain of approximately 26 times. The circuit is intended for use with a high impedance microphone, and the total voltage gain is sufficient to give an output in excess of 1 volt RMS with most microphones of this type. RV1 can be used to give a lower level of gain if necessary. An excellent signal to noise ratio is obtained by using a low noise bipolar operational amplifier in the IC1 position and a biFET type in the IC2 position.

an LM13700N dual transconductance operational amplifier is used as the basis of the limiter. IC3a is used as a straight forward current controlled amplifier and under quiescent conditions this is biased by R15 so that it has approximately unity voltage gain. R14 biases the linearising diodes of IC3a and gives improved distortion and large signal handling performance.

IC3b is used as a straight forward amplifier, and the gain of this stage can be varied by means of RV2. C8 couples the output of this amplifier t the input of the Darlington Pair emitter follower output stage of IC3b. This drives TR1 via R23 and R24, but under quiescent conditions TR1 is cut off due to the low bias level supplied to the emitter follower buffer stage by R21 and R22.

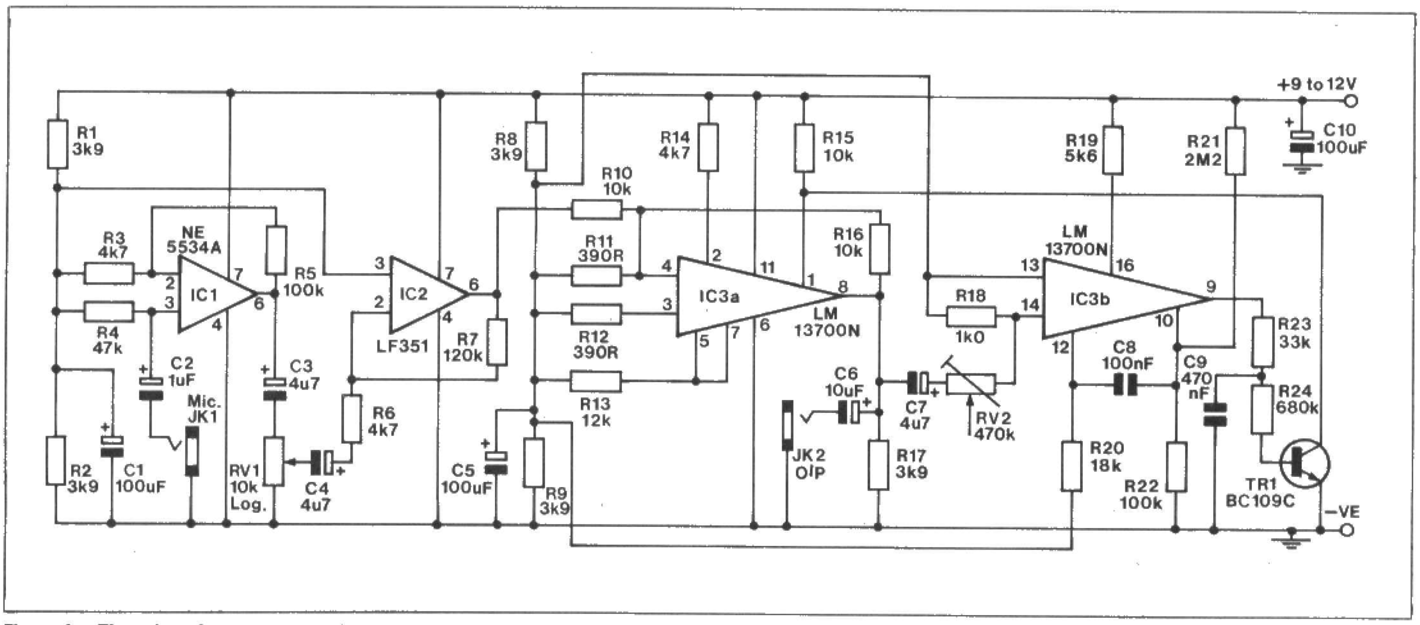


Figure 1. The microphone pre-amp/limiter circuit diagram.

However, on positive output half cycles from IC3b, provided the signal level is high enough, TR1 will be biased into conduction. It then reduces the bias current to IC3a so that its gain is reduced and the required limiting action is obtained. C9 integrates the pulses from IC3b, but the values of C9, R23 and R24 have been chosen to give fast attack and decay times so that the limiting action is unlikely to be noticed unless a very severe overload occurs.

RV2 is adjusted to give the desired limiting level, and this can be any practical value above about 20 millivolts RMS. Raising the input signal 20dB above the limiting threshold gives an increase of less than 2dB at the output. A substantial overload could result in the signal at the output of IC2 being clipped, but such an overload is unlikely to occur in normal use. An 18 volt supply gives the greatest overload margin, but in practice a 9 volt supply will usually be perfectly adequate.

PSEUDO STEREO AM RADIO

Resistors — All 0.4W 1% metal film			
R1,6,7,9,10	100k	(5 off)	(M100K)
R2	2k7		(M2K7)
R3	560R		(M560R)
R4,11	100R	(2 off)	(M100R)
R5,12	1R0	(2 off)	(M1R0)
R8	1k0		(M1K0)
RV1,3	Pot log. 10k	(2 off)	(FW22Y)
RV2	Pot lin. 100k		(FW05F)
Capacitors			
C1,6,8,12,13,15	100uF 25V P.C. electrolytic	(6 off)	(FF11M)
C2,9,16	100nF Polyester	(3 off)	(BX76H)
C3,11	10nF Polyester	(2 off)	(BX70M)
C4	470nF Polyester		(BX80B)
C5,10	2u2F 63V P.C.electrolytic	(2 off)	(FF02C)
C7, 14	330pF ceramic	(2 off)	(WX62S)
VC1	AM Varitune 500pF		(YQ24B)
Semiconductors			
D1,2	1N4148	(2 off)	(QL80B)
IC1	ZN414		(QL41U)
IC2,4	TBA 820M	(2 off)	(WQ63T)
IC3	741C		(QL22Y)
Miscellaneous			
JK1,2	¼" Jack socket	(2 off)	(HF90X)
	Jack plugs	(2 off)	(HF85G)
S1	Sub-min toggle A		(FH00A)
L1	MW/LW Aerial		(LB12N)
	HP7 Batteries	(4 off)	

NI CAD CHARGER

Resistors — All 0.4W 1% metal film			
R1,5	220k	(2 off)	(M220K)
R2	4M7		(M4M7)
R3,6	10k	(2 off)	(M10K)
R4,7	100k	(2 off)	(M100K)
R8	47k		(M47K)
Capacitors			
C1	1uF 5% Polycarbonate		(WW53H)
C2	1nF Polycarbonate		(WW22Y)
C3	10nF Polyester		(BX70M)
C4	100uF 25V P.C. electrolytic		(FF11M)
C5,6	220nF Polyester	(2 off)	(BX78K)
C7	470uF 25V P.C. electrolytic		(FF16S)
Semiconductors			
D1,2	1N 4002	(2 off)	(QL74R)
D3	1N 4001		(QL73Q)
TR1	BC109C		(QB33L)
TR2	BC179		(QB54J)
IC1,3	555	(2 off)	(QH66W)
IC2	4020BE		(QX11M)
IC4	uA78M12UC		(QL29G)
Miscellaneous			
RLA	Relay flat 12V		(HY20W)
T1	Min Tr 15V		(WB15R)
LS1	Loudspeaker 64R		(WF57M)
FS1	Fuse 20mm 250mA		(WR01B)
	Safuseholder 20		(RX96E)

PARTS LIST ADD/SUBTRACTER

Resistors — all 0.4W 1% Metal film			
R1,9,10	10k	3 off	(M10K)
R2	1k0		(M1K0)
R3	110R		(M110R)
R4-8	15k	5 off	(M15K)
RV1,2	Pot lin. 10k	2 off	(FW02C)
Capacitors			
C1-3	4u7F 63V P.C. electrolytic	3 off	(FF03D)
C4	100nF polyester		(BX76H)
Semiconductors			
IC1	LF353		(WQ31J)
Miscellaneous			
S1	Switch rotary SW3B		(FF76H)
S2	Switch sub-min toggle E		(FH04E)
JK1-3	¼" jack socket	3 off	(HF90X)
	Jack plugs	3 off	(HF85G)

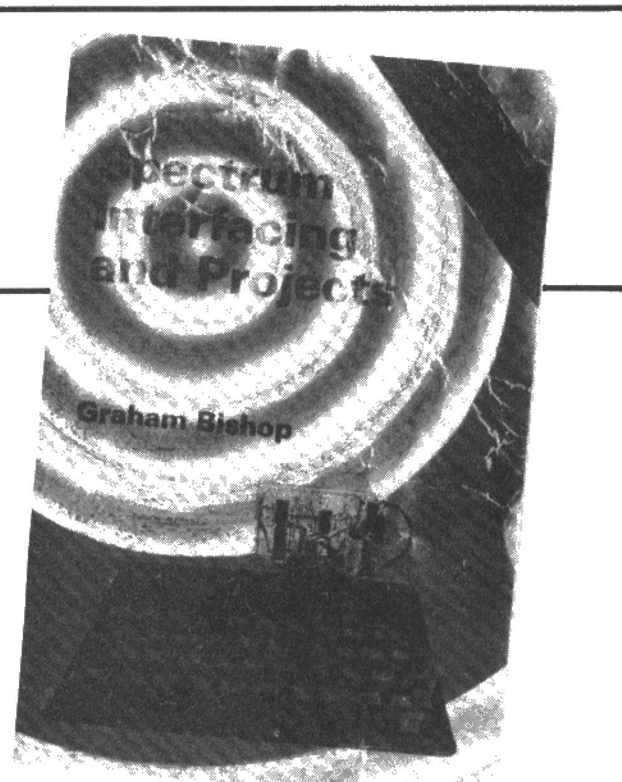
THE SYNDRUM INTERFACE PARTS LIST

Resistors — All 0.4W 1% Metal film			
R1,11,15	4k7	3 off	(M4K7)
R2	1k0		(M1K0)
R3	180k		(M180K)
R4	150k		(M150K)
R5,13,14,17	10k	4 off	(M10K)
R6,7	2k2	2 off	(M2K2)
R8	3M3 ⅓W 5% carbon film		(B3M3)
R9,10	47k	2 off	(M47K)
R12	2M2 ⅓W 5% carbon film		(B2M2)
R16	3k3		(M3K3)
RV1	Pot log 100k		(FW25C)
RV2	Pot lin 22k		(FW03D)
RV3	Pot log 2M2		(FW29G)
Capacitors			
C1	470uF 25V PC electrolytic		(FF16S)
C2,3,4	100nF polyester	3 off	(BX76H)
C5,7	10uF 35V PC electrolytic	2 off	(FF04E)
C6	2n2 polycarbonate		(WW24B)
Semiconductors			
D1,2	1N4002	2 off	(QL74R)
D3	BZY88C5V1		(QH07H)
D4	1N4148		(QL80B)
TR1	BC109C		(QB33L)
IC1	uA78L15AWC		(QL27E)
IC2	555		(QH66W)
IC3	CA3240E		(WQ21X)
IC4	CA3140		(QH29G)
Miscellaneous			
T1	Min Tr. 15v		(WB15R)
FS1	Fuse 20mm 100mA		(WR00A)
	Safuseholder 20		(RX96E)
S1	Switch rocker DP		(YR69A)
S2,3	Switch sub-min toggle A	2 off	(FH00A)
JK1-3	¼" jack socket	3 off	(HF90X)
Mic 1	Crystal earpiece		(LB25C)
	Jack Plug	3 off	(HF85G)

MICROPHONE PRE-AMP/LIMITER

Resistors — All 0.4W 1% metal film			
R1,2,8,9,17	3k9	(5 off)	(M3K9)
R3,6,14	4k7	(3 off)	(M4K7)
R4	47k		(M47K)
R5,22	100k	(2 off)	(M100K)
R7	120k		(M120K)
R10,15,16	10k	(3 off)	(M10K)
R11,12	390R	(2 off)	(M390R)
R13	12k		(M12K)
R18	1k0		(M1K0)
R19	5k6		(M5K6)
R20	18k		(M18K)
R21	2M2 ⅓W5% Carbon film		(B2M2)
R23	33k		(M33K)
R24	680k		(M680K)
RV1	Pot log. 10k		(FW22Y)
RV2	Hor. Preset S-Min 470k		(WR63T)
Capacitors			
C1,5,10	100uF 25V P.C. electrolutic	(3 off)	(FF11M)
C2	1uF 100V P.C. electrolytic		(FF01B)
C3,4,7	4u7F 63V P.C. electrolytic	(3 off)	(FF03D)
C6	10uF 35V P.C. electrolytic		(FF04E)
C8	100nF Polyester		(BX76H)
C9	470nF Polyester		(BX80B)
Miscellaneous			
TR1	BC109C		(QB33L)
IC1	NE5534A		(YY68Y)
IC2	LF351		(WQ30H)
IC3	LM13700N		(YH64U)
JK1,2	¼" Jack socket	(2 off)	(HF90X)
	Jack plugs	(2 off)	(HF85G)

SPECTRUM INTERFACING AND PROJECTS



A new book of interfacing projects for the Sinclair Spectrum computer by Graham Bishop is now available. We can supply printed circuit boards or complete kits for all three major projects. These are an analogue to digital converter, a digital to analogue converter and a latch. All plug directly into the Spectrum expansion port. The book contains lots of other projects to build, ranging from joysticks to voice recording and light pen to servos.

The following special parts are available for use with this book.

Analogue to Digital Converter Project

7581ADC	**QY56L**	**Price £19.95**
ADC PCB	**GB33L**	**Price £2.80**
Complete Kit	**LK26D**	**Price £25.99**

(Note that the Edge Connector code on page 134 should be FG23A).

Digital to Analogue Converter Project

DAC PCB	**GB34M**	**Price £2.84**
Complete Kit	**LK25C**	**Price £13.95**

Latch Project

Latchcard PCB	**GB32K**	**Price £2.20**
Complete Kit	**LK24B**	**Price £6.50**

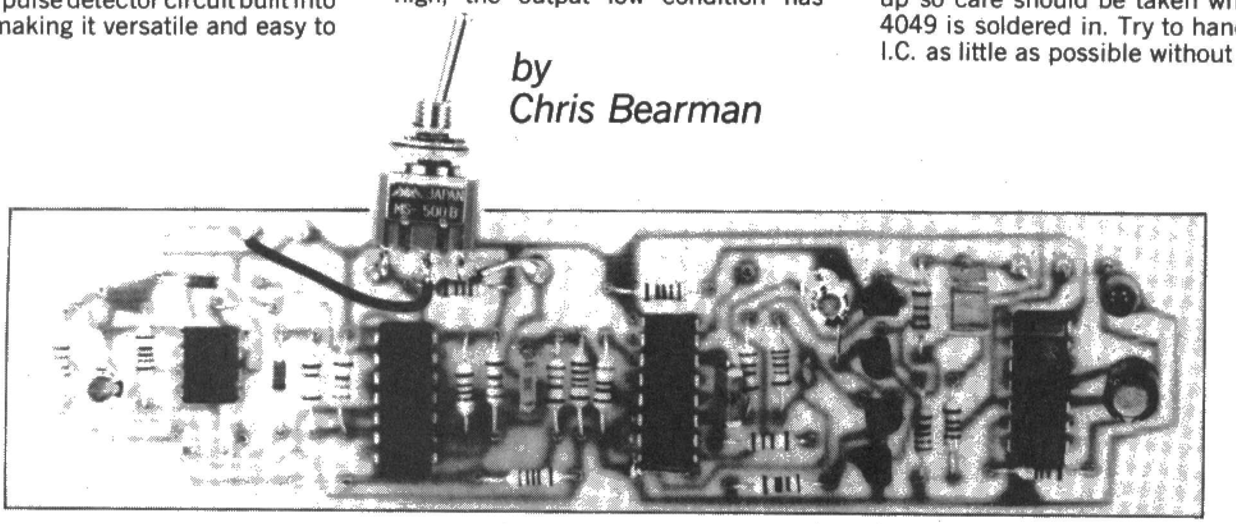
Book

The book itself is available as

WM52G Price £7.63*NV*

LOGIC PULSER

by
Chris Bearman



★ Makes checking IC functions much simpler
★ Inexpensive addition to your test gear ★ Easy-to-use

For anyone who builds or services circuitry incorporating TTL logic, a pulser is an invaluable piece of test equipment. This device enables the user to stimulate logic gate inputs when they are already connected into a circuit. This way it is often possible to test an I.C. which otherwise would have had to be removed with the associated trouble and possibility of damage. A logic pulser is usually used in conjunction with a logic probe which will locate and display the signal produced. The TTL pulser has the advantage of already having a pulse detector circuit built into it, thus making it versatile and easy to use.

The pulser supplies a very short, but powerful, pulse each time the switch is depressed, the current of which will exceed half an Amp. This current is more than enough to overcome any TTL output, but could normally damage the I.C. being overridden, and therefore the pulse width is deliberately limited to a very short period. When the switch is depressed, the output will firstly fall to a logic low, and will then rise to give a logic high, so as to toggle the gate input regardless of the state it was previously being held at. When the pulse is completed the pulser's output will return to it's former high impedance state. By holding down the switch, a stream of pulses will be clocked out at around fifty hertz, which can be very useful when checking counting circuits, etc.

Circuit Description

A total of four I.C.'s and four transistors are used in the circuit, which is built on an etched printed circuit board. Around twenty-five milliamps at five volts is required from the host equipment's power supply for operation.

The first half of the 7400 is used to de-bounce the biased toggle switch. Output pin 11 applies a negative edge to pin 5 of the 4049 via C1. The signal now travels in two different paths. Firstly, inverter output pin 6 switches on the transistors TR2 and TR4, so pulling down the output to logic '0'. The same signal from inverter output pin 4 eventually switches on transistors TR1 and TR3 as well, but this is delayed by the extra inverter, (pins 9 and 10) and capacitor C5. By the time that these two transistors conduct to take the output high, the output low condition has terminated. On completion of the high going pulse, the second pair of transistors are turned off, therefore allowing the output to return to it's high impedance state.

If the switch is held down for more than half a second, the clock generator IC3 will come into operation. Firstly C2 is allowed to charge up via resistor R9 until the 555 triggers. When this happens, its output (pin 3) will go low, so changing the state of output pin 6 of the R.S. flip-flop. This will now allow the 555 to oscillate in the astable mode, acting on inverter pin 5 via 1K ohm resistor R5. It will be noticed that two of the inverters in the 4049 package are not used but their inputs must be tied down to prevent any damage to the I.C. due to static build up.

The pulse detector part of the circuit is designed around a 74121 I.C. This I.C. is a monostable multivibrator which is used to extend the pulse detected to a length which may be observed on an LED. Each time a pulse is detected the LED will flash on.

Construction

The components for the pulser are all to be mounted onto a single etched printed circuit board with the exception of the LED and the toggle switch which should be fitted into the housing. The resistors should be soldered in first, followed by the capacitors. Ensure that the correct polarity is observed when fitting the tantalum and electrolytic types. Solder in the four links on the board with pieces of wire. Putting aside the 4049 CMOS inverter, solder in the rest of the semiconductors. Careless handling of MOS devices can cause device destruction due to static build-up so care should be taken when the 4049 is soldered in. Try to handle the I.C. as little as possible without touching the pins once it has been removed from it's protective casing. Solder it in carefully using an earthed soldering iron. Lastly fit the vero pins to the board and connect up the LED and the switch. The cathode of the LED will be found to be adjacent to the flat on the body. The normally closed connection to the switch is that which is furthest from the toggle when in the biased position, the common connection is that in the centre.

Testing

Before applying power, check the circuit carefully for possible mistakes which could have been made in the assembly. Check in particular that the I.C.'s and the transistors are the right way round. If all appears well, connect a five-volt supply to the pulser with a milli-ammeter in series, observing that the current consumption should be in the order of 25-30mA. If it is very much higher than this, remove the power and look for any errors. Assuming that the consumption is correct, switch off, remove the meter and temporarily connect a wire from the pulse 'in' pin to the pulse 'out' pin. Reconnect the

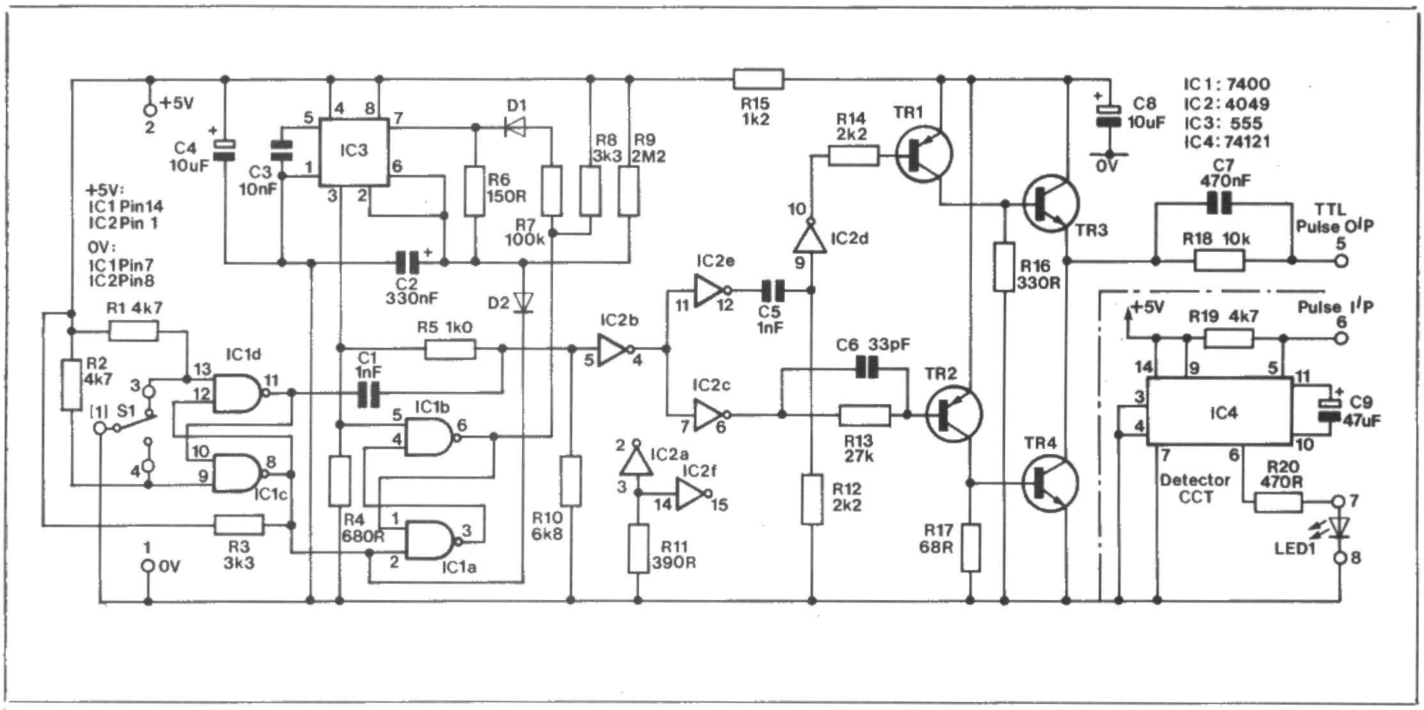


Figure 1. Circuit diagram

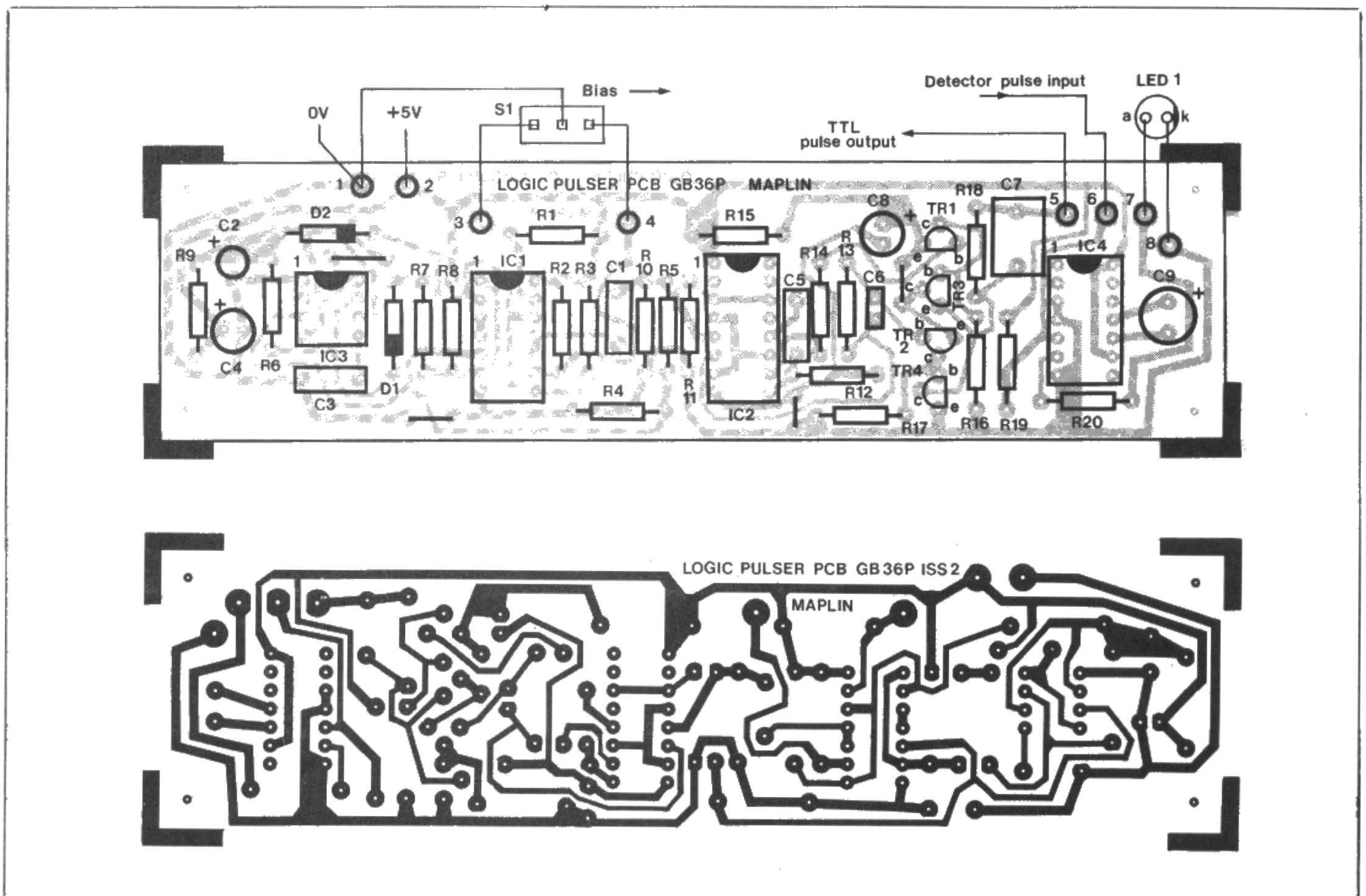


Figure 2. PCB layout and wiring diagram

supply and toggle the switch once. The LED should flash on once and go out. Now hold the switch in the 'on' position. The LED should flash once, then after half a second delay a stream of continuous pulses should be seen. Now temporarily connect a 10 ohm resistor firstly between the output of the pulser and ground, and then between the output and the +5V rail. Toggling the switch with the resistor in both of these positions should give the same results as found without it connected. This test shows the ability of the pulser to force both logic states sinking a current of over half an Amp. Now remove the 10 ohm resistor and the wire between the pulse in and out. The pulser is now ready for use.

Using The Pulser

Connect the supply from the circuit under test to the pulser. Now connect the pulse 'in' to the output of the gate to be tested and the pulse 'out' to the gate input. If the gate is working correctly, the LED will flash as the switch is toggled. To test a counter, connect the pulse 'in' to one of the counter outputs and the pulse 'out' to the counter input. When the switch is held down, the stream of pulses will keep clocking the counter enabling the pulse 'in' to be moved to the other outputs to check that they are all active. Alternatively each state of the counter may be checked by stepping through at the rate of one pulse at a time.

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STEREO disco console, pro-built, 120w.p.c. new, £245; extended minisonic synth, £125; saxon 150w slave-amp, £60; Giannini 12-string acoustic guitar, £85. Tel. (0375) 674089.

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WANTED for young enthusiast: Oscilloscope, must be working but cheap. If local will collect. Contact Martin Pocock, 3 Clifford Crescent, Taunton, Somerset.

WANTED Circuit Diagram for a Portable Transceiver to operate at 78.1 mHz A.M. A project for local A.T.C. Cadets so must be relatively simple and reliable. K. Rees. Tel Shrewsbury 59340.

NON-WORKING or cheap micro wanted. Most digital/analogue components for sale. Tel. Eve/WE 01-902 4206.

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PARTS LIST FOR LOGIC PULSER

Resistors — All 0.4W 1% metal film unless specified			
R1,2,19	4k7	3 off	(M4K7)
R3,8	3k3	2 off	(M3K3)
R4	680R		(M680R)
R5	1k0		(M1K0)
R6	150R		(M150R)
R7	100k		(M100K)
R9	2M2 0.3W 5% carbon film		(B2M2)
R10	6k8		(M6K8)
R11	390R		(M390R)
R12,14	2k2	2 off	(M2K2)
R13	27k		(M27K)
R15	1k2		(M1K2)
R16	330R		(M330R)
R17	68R		(M68R)
R18	10k		(M10K)
R20	470R		(M470R)
Capacitors			
C1,5	1nF polycarbonate	2 off	(WW22Y)
C2	330nF tantalum		(WW57M)
C3	10nF polycarbonate		(WW29G)
C4,8	10uF 35V PC electrolytic	2 off	(FF04E)
C6	33pF ceramic		(WX50E)
C7	470nF polycarbonate		(WW49D)
C9	47uF 25V PC electrolytic		(FF08J)
Semiconductors			
D1,2	1N4148	2 off	(QL80B)
TR1,2	2N3703	2 off	(QR27E)
TR3,4	2N3704	2 off	(QR28F)
IC1	7400		(QX37S)
IC2	4049UBE		(QX21X)
IC3	NE555		(QH66W)
IC4	74121		(QX73Q)
Miscellaneous			
	PC board		(GB36P)
	Veropin 2141	1 Pkt	(FL21X)
S1	SPCO (Biased) Sub-min toggle		(FF70M)
LED1	LED red		(WL27E)
	LED clip		(YY40T)

A complete kit of all parts is available.
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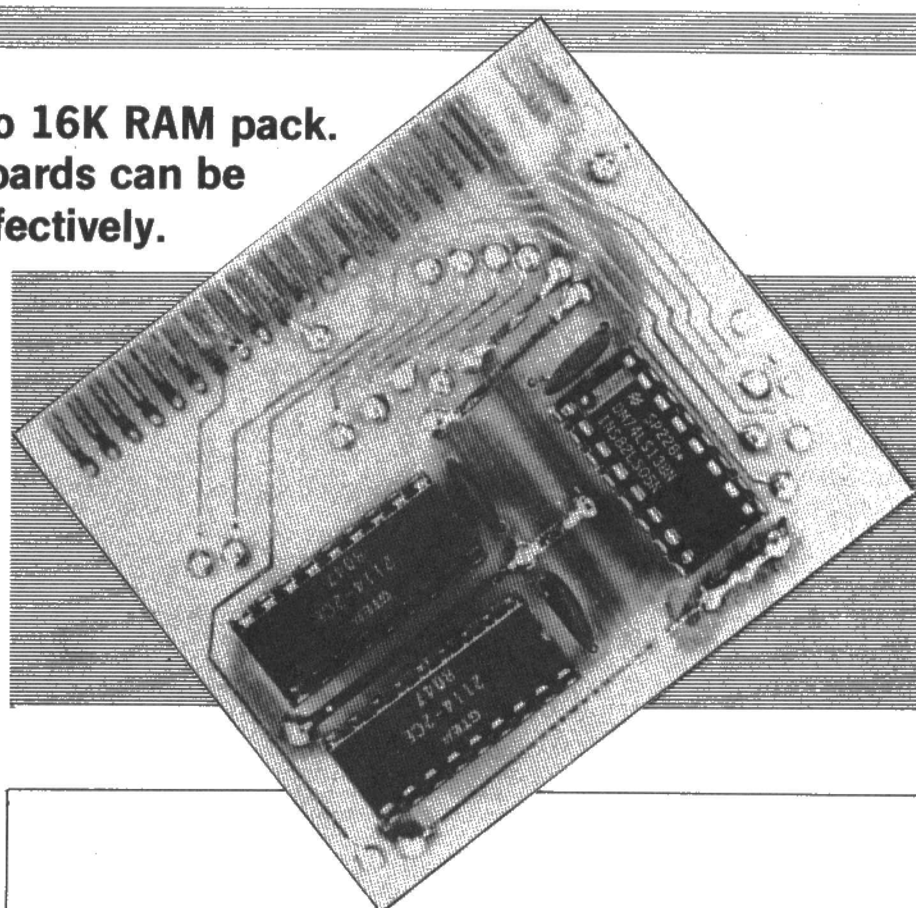
ZX 81 Extendi-RAM

★ **Low cost alternative to 16K RAM pack.**
★ **Up to four 1K RAM boards can be used together cost-effectively.**
★ **Easy to build.**

by Dave Goodman



For ZX81 owners who do not yet have a 16K RAM pack, our 1K module provides a small, low cost alternative for increased program storage area which can be extended in 1K blocks.

The standard computer contains 1K (1024) Bytes of static memory, out of which some 125 Bytes are used for system variables. A full screen of characters (32 x 22) uses 704 Bytes, and, allowing for program variables expanding during a program run, it can be seen that very little space is left in RAM for BASIC programs!

One solution is to fit a 16K to 32K RAM extension, which may prove expensive to computerists on a low budget. If only a few K of RAM is required, however, this module will meet the requirement.

If the instruction PRINT PEEK 16388 + 256 * PEEK 16389 is entered directly into the ZX81, the address 17408 will be printed, this being the first byte above RAMTOP.

The two system variables at addresses 16388 and 16389 together contain the size of RAM available for use, and, as RAM address begins at 16384, the highest memory address available in 1K is 17407. A further 1K RAM will need to begin at address 17408 to 18431 etc. Track pins A to F select the required memory block, and only one of these pins should be inserted in each module if more than one module is to be used (see table 1).

Table 1.

Track Pin	Memory Size	Memory Map
ZX81	1K	16384 to 17407
A	2K	17408 to 18431
B	3K	18432 to 19455
C	4K	19456 to 20479
D	5K	20480 to 21503
E	6K	21504 to 22527
F	7K	22528 to 23551

Use A on one module, B on a second module, C on a third module, etc.

Construction

Insert the 27 track pins (omitting A to F), the 3 IC holders, and the 3 disc

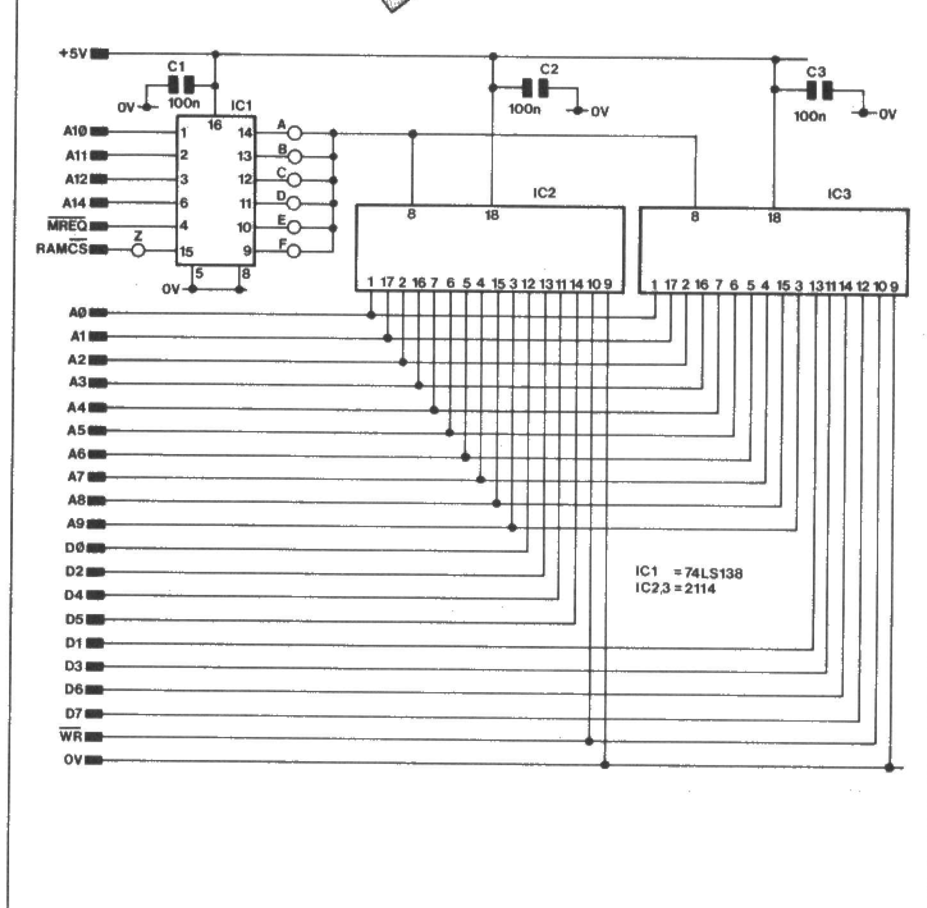


Figure 1. Circuit diagram.

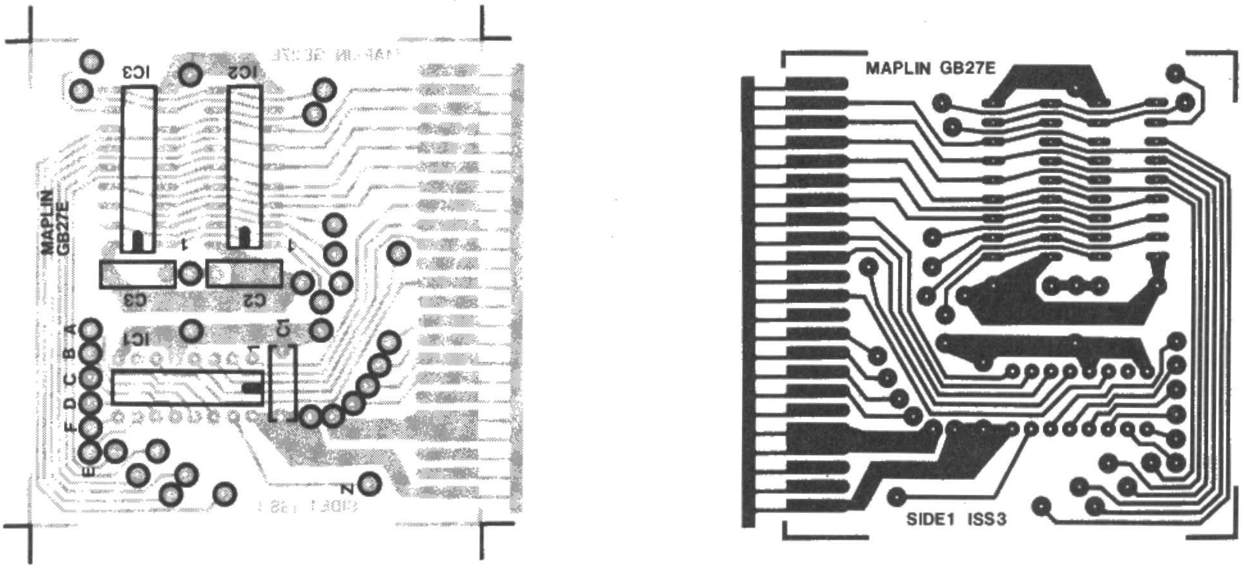


Figure 2. PCB layout and overlay.

capacitors. Carefully solder all connections, then clean excess flux from the PCB. Insert one of the pins A to F (see table 1) and the 3 ICs. Plug the module into the extendiboard, or fit a 2 x 23 way socket (RK35Q) to the edge connector and connect to the ZX81. Switch on, and run the RAMTOP test. Note that the address printed will be one higher than shown in table 1. Further modules can be fitted provided that an extension motherboard is available for the expansion port.

PARTS LIST FOR ZX81 1K EXTENDIRAM

Capacitors			
C1,2,3	100nF disc ceramic	3 off	(BX03D)
Semiconductors			
IC1	74LS138		(YF53H)
IC2,3	2114	2 off	(QW12N)
Miscellaneous			
	ExtendiRAM P.C.B.		(GB27E)
	18 pin DIL skt	2 off	(HQ76H)
	16 pin DIL skt		(BL19V)
	Track pin	1 pkt	(FL82D)

A complete kit of all parts is available.
Order As LK16S (ZX81 1K ExtendiRAM kit) Price £5.20

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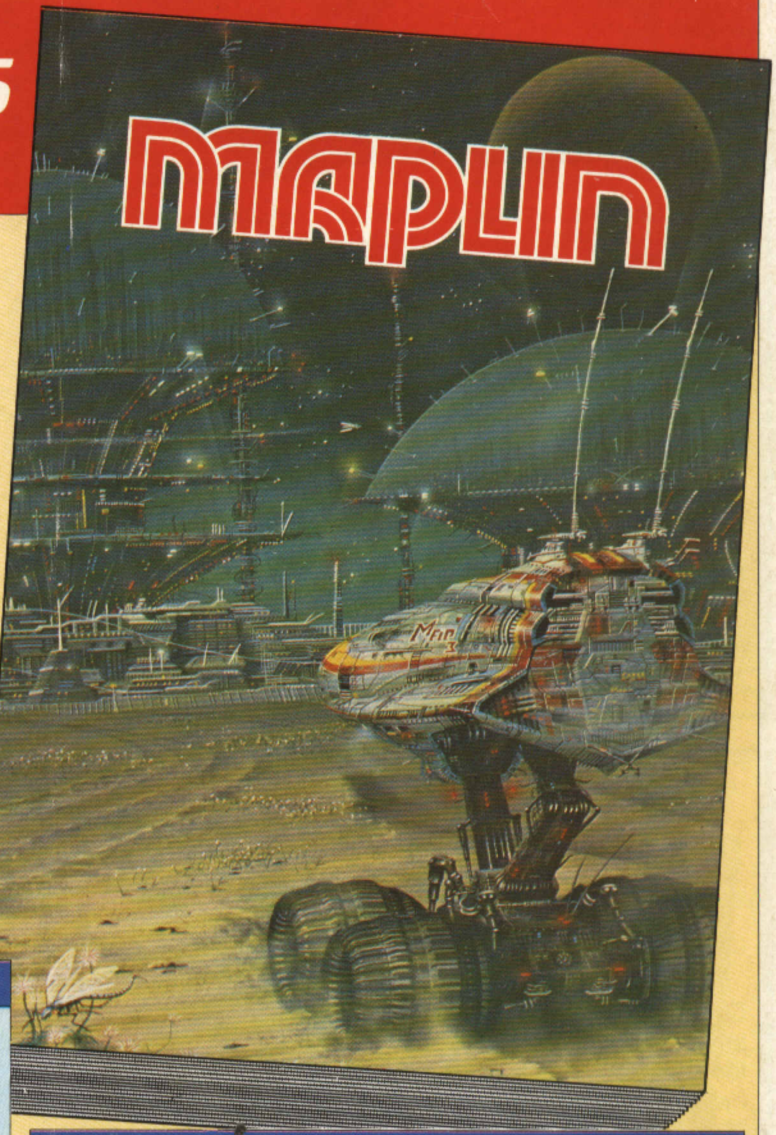

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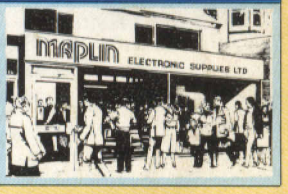

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